

FRONT-LOADING THE PAYMENT OF UNEMPLOYMENT BENEFITS

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Author's Note

This paper will no longer be updated.
The results have been superseded by the new paper titled "Penalty vs. Insurance: A Reassessment of the Role of Severance Payments in an Economy with Frictions"



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Front-loading the Payment of Unemployment Benefits ^{*}

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Abstract

We study the effects of front-loading the payment of unemployment benefits in an equilibrium matching framework with precautionary savings. Front-loading the benefit system trades off fewer means to smooth consumption at long unemployment durations for improved insurance upon job loss. In the United States where jobless spells are typically frequent but short, we find that front-loading the benefit system yields significant welfare gains for new benefit recipients. The gains are lower in the aggregate, but are not completely offset by general equilibrium effects. Comparison with a search effort model shows that the welfare figures are not specific to matching frictions.

Keywords: Unemployment Insurance, Precautionary Savings, Labor-Market Frictions, Welfare Effect

JEL codes: E21, I38, J63, J65

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1 Introduction

In the United States, as in most industrial countries, unemployment compensations are usually paid to the unemployed on a regular basis throughout the duration of benefit reciprocity. This feature of benefit payments, however, is likely suboptimal in an environment where workers move repeatedly between employment and unemployment. On the one hand, higher levels of benefits at the start of the unemployment spell would assist with consumption-smoothing upon job loss. Reduced benefit payments at longer unemployment durations, on the other hand, would help improve re-employment rates. The second argument is well-understood when re-employment depends on unobservable search efforts of the unemployed.¹ Absent moral hazard, Coles and Masters (2006) show that the argument also holds when, instead, workers are brought back into employment by a matching function. Against this background, it is an open question whether, under matching frictions, more generous benefit payments after job loss would improve welfare when workers can also self-insure against risk. That is, if unemployment spells are frequent and entail a significant drop in earnings upon job loss, then workers face a strong incentive to accumulate precautionary savings. This has potential to mitigate, if not offset, the improvements that would accrue from more generous benefit payments after job loss. In this paper, we use a framework that embodies these trade-offs and take a first step towards addressing this question.

We build on the recent synthesis of the Mortensen-Pissarides and Bewley-Huggett-Aiyagari models proposed by Krusell, Mukoyama and Şahin (2010). This framework is a natural candidate to assess the welfare effects of varying the payment of unemployment benefits in a frictional labor market. The key elements we add to this construct are: (i) a two-tier benefit system that stands similar to real-life unemployment insurance systems in countries such as, e.g., the United States, (ii) a stochastic life-cycle structure so as to generate realistic consumption-saving decisions and (iii) heterogeneity in discount factors to capture differences in abilities to build up savings.

In the model that results, closed-form solutions to characterize the welfare effects of unemployment benefits are typically beyond reach. Therefore, we proceed with a numerical analysis using a version of the model calibrated to US data and policies.²

We specialize the discussion of varying the payment of unemployment benefits by duration to a simple redesign of the system, namely front-loading the payment of these benefits. Specifically, the numerical experiments compare welfare in the environment parametrized to the current US system against environments where new benefit recipients can collect part of the expected cumulative sum of benefits as an initial one-off payment. The motivation for focusing on front-loading rather than more sophisticated schemes is as follows. When workers experience repeated spells of unemployment, an initial benefit level close to the wage helps smooth consumption upon job

¹A review of the related literature (including the literature that elaborates on moral hazard arguments) is provided in the second part of the introduction.

²The parameters of the unemployment insurance system embedded in the model are readily mapped onto some defining characteristics (generosity, duration, etc.) of the system in place in the US. Further, the US unemployment insurance system has been the object of numerous investigations using calibrated incomplete market economies. These provide basis for comparisons with the results reported in Sections 4 and 5 of the paper.

loss, as noted in the opening paragraph. In subsequent periods of unemployment, a declining time-path instead of a constant flow payment has potential to improve re-employment rates. Optimal unemployment insurance would take into account both the intercept and the subsequent time path of benefits. This problem is too complex to solve in a world where agents can save and transfer wealth across periods, but front-loading the benefit system comes closest to capturing the main incentives. That is, front-loading benefits improves insurance at the start of the unemployment spell and reduces benefits in subsequent periods to leave their cumulative sum unchanged relative to the baseline scenario. Thus, we focus on varying the intercept of unemployment benefit payments while removing one degree of freedom (the time path of benefit payments). In this respect, our approach is similar to Hansen and İmrohoroğlu (1992): we study the effects of a restricted set of policy instruments within a rich calibrated incomplete market model.

The analysis has three main results. First, front-loading the benefit system yields substantial welfare gains for new entrants into the benefit system. Although a partial equilibrium metric, the perspective of new benefit recipients is insightful in understanding the mechanisms at play. We show that removing the constant flow payment of unemployment benefits is harmful due to the lack of comparable safety nets, but that this is more than offset by improved insurance upon job loss. Two features of the benchmark model explain this result: (i) providing benefits up-front does not substitute one for one to private self-insurance against job loss and (ii) jobless spells are typically short-lived in the US labor market. To illustrate the second point, we tabulate the welfare gains of front-loading the benefit system after increasing the duration of constant unemployment benefits in the benchmark environment. We find that the gains become significantly larger, which is consistent with the risk of long-term unemployment being second order.

Second, after averaging welfare changes across all workers (not only new benefit recipients), we find lower but still positive welfare figures. In the aggregate, the order of magnitude is about one tenth of a percent in lifetime consumption. A decomposition of this figure into the underlying general equilibrium effects reveals the following. Front-loading the payment of unemployment benefits brings a welfare gain of 0.6 percent of lifetime consumption directly through improved insurance, and a further indirect gain of 0.2 percent through higher job-finding rates (higher labor market tightness). The downward adjustment in the interest rate has negligible welfare effects. Finally, the increase in the tax rate used to sustain the unemployment insurance system implies a welfare loss of 0.7 percent of lifetime consumption. If eligibility to unemployment benefits is unrestricted, however, the increase in the tax rate is steeper and the welfare loss becomes larger. Although beyond the scope of this paper, this suggests that front-loading the benefit system is not free of concerns with, e.g., screening new entrants into the benefit system.

The third result pertains to the relationship between the welfare effects uncovered by the model and the nature of labor market frictions it embodies. That is, under matching frictions, an unemployed worker cannot control his/her probability to regain employment. To investigate how this affects the welfare figures, we construct and evaluate another incomplete market model where labor market frictions stem from costly search efforts – another standard way of modelling labor market frictions. In this environment, unemployment durations reflect directly the privately-optimal

search efforts of the unemployed. It follows that front-loading the benefit system has potential to raise employment and output substantially more than under matching frictions. This insight is confirmed by the calibrated version of the model. Meanwhile, we find welfare figures that are similar to those obtained in the matching equilibrium because the increase in search effort entails a large utility cost. Thus, the welfare figures we report are compatible with figures obtained with a different specification for labor market frictions.

The paper is organized as follows. The remainder of the Introduction reviews the related literature. Section 2 presents the model economy. Section 3 proceeds with the calibration. Section 4 contains the main numerical experiments and a discussion of the results. Section 5 draws a comparison by repeating the experiments in a search-effort model. Section 6 concludes.

Related literature

This paper is directly related to a body of research that studies optimal unemployment insurance in an equilibrium matching framework.³ Optimality in this setup is an object of keen discussions that illustrate the importance of wage-setting assumptions. For instance, Fredriksson and Holmlund (2001) study a two-tier benefit system with standard Nash bargaining and find that unemployment insurance should decrease with duration to encourage search effort among the uninsured unemployed. Cahuc and Lehmann (2000), on the other hand, argue that unemployment benefits should increase with duration when wages are bargained by a union of insiders: since their bargaining threat point is the value of being laid off, reducing early benefits allows to lower the pressure on equilibrium wages.⁴ A common theme in these two papers, however, is that the matching function is combined with unobservable search efforts;⁵ this makes it difficult to isolate the role of each component in explaining their results. Coles and Masters (2006) rule out search effort and show that a decreasing time-path of benefits is desirable in a matching equilibrium with strategic wage bargaining. Coles (2008) re-introduces search effort and demonstrates that optimal unemployment benefits fall with duration when standard Nash bargaining is used instead of the insider-outsider distortion of Cahuc and Lehmann (2000). The paper by Coles (2008) provides one further insight by showing that optimal unemployment benefits should start from a level equal to the wage, i.e., provide full insurance upon job loss.

In the four papers just described, it is assumed that workers are risk averse but that they do not have access to savings. Ruling out savings is useful for obtaining tractability but it also precludes self-insurance strategies. By contrast, the papers by Krusell, Mukoyama and Şahin (2010) and Mukoyama (2013) consider the implications of unemployment insurance in a matching frame-

³Albrecht and Vroman (2005) and Akin and Platt (2012) discuss the effects of time-varying unemployment benefits in search models with wage posting. Constructing an equilibrium framework with wage posting alongside precautionary savings would complicate the analysis substantially. For this reason, we limit the discussion of the equilibrium search-matching literature to papers that rely on wage bargaining.

⁴Another difference between Fredriksson and Holmlund (2001) and Cahuc and Lehmann (2000) is that the latter replace the utilitarian welfare function by a Rawlsian criterion. The authors argue that the relevant metric is the welfare change for the long-term unemployed induced by a change in the unemployment rate.

⁵That is, the matching function takes as inputs not only the number of vacancies and unemployed workers, but also the endogenous search efforts of the unemployed.

work with precautionary savings. They analyze steady-state (Krusell, Mukoyama and Şahin) and transitional (Mukoyama) effects of a constant flow payment of indefinite duration. In this paper, we elaborate on their framework to consider the steady-state effects of policy reforms that maintain the cumulative sum of benefits unchanged relative to the US baseline scenario.

The idea that benefits should become less generous at prolonged spells of unemployment is a long-standing result of the principal-agent literature (Shavell and Weiss, 1979; Hopenhayn and Nicolini, 1997). That is, search efforts – unobserved by the Planner – can be deemed too low at long unemployment durations and this could be avoided with a declining time path of benefits. Another idea coined by this literature is that consumption while unemployed should be distinguished from unemployment benefits. To make the distinction operational, workers must have the ability to save. In Shimer and Werning (2008) for example, there is free access to a riskless bond (workers can save and borrow) and the authors show that a constant unemployment benefits is optimal under CARA utility. Similar results are not available when there is a liquidity constraint (i.e., when workers cannot borrow beyond a limit). In fact, Kocherlakota (2004) argues that solving the principal-agent problem in this case is not computationally feasible.

The optimal contracting approach offers important analytical insights, but it operates in a partial-equilibrium world with: exogenous wages, no congestion externality and a single-spell of nonemployment. As already mentioned, we instead adopt a quantitative general-equilibrium approach while considering a restricted set of policy instruments.

In an early study, Wang and Williamson (1996) adopt a similar approach and find that benefits should decrease with duration in a model with repeated spells of unemployment and unobserved search efforts. The welfare statements that can be made using their model are limited insofar as the model does not allow agents to access savings. In subsequent investigations, Wang and Williamson (2002) and Young (2004) discuss the effects of unemployment insurance in a general equilibrium setting with both search efforts and precautionary savings. Another paper in this vein of the literature is Abdulkadiroğlu, Kuruşçu and Şahin (2002): they rule out search efforts but consider moral hazard in relation to the quit behavior of workers to examine long-term insurance plans. They report that benefits after two periods of unemployment should be very low. However, none of these papers discuss front-loading along the line of this paper. For this reason, in Section 5 of the paper, we build a model economy similar to Young (2004) so as to tabulate the effects of front-loading the benefit system in the presence of unobserved search efforts and savings. The objective in that section is to offer grounds for comparison with the main results, which are based on the equilibrium matching framework.

2 Model economy

The model builds on the framework analyzed by Krusell, Mukoyama and Şahin (2010). We accommodate this framework to include: (i) a realistically-calibrated unemployment insurance system, (ii) a stochastic life-cycle structure and (iii) heterogeneity in workers' discount factors. For expositional purposes, the third feature is deferred to the calibration section of the paper.

2.1 Environment

Demographics and preferences

One side of the market is populated by overlapping generations of individuals who work and then retire from the labor market.⁶ Working and retirement life spans are uncertain: each period, individuals are subjected to a probability $\sigma > 0$ of retiring when in the labor force, and to a probability $\varsigma > 0$ of dying after they have retired. A fraction of newborns enters the economy in every period to maintain the measure of the population at a constant unit level.

Workers and retirees have their momentary utility function defined over consumption streams $c > 0$. They maximize:⁷

$$\mathbb{E}_0 \sum_{t=0}^{+\infty} \beta^t \log(c_t) \quad (1)$$

where \mathbb{E}_0 denotes mathematical expectation conditional on information at time 0 and β is an individual's subjective discount factor.

On the other side of the market, there is a continuum of infinitely-lived entrepreneurs. They maximize the expected value of the discounted sum of profit streams π :

$$\mathbb{E}_0 \sum_{t=0}^{+\infty} \left(\frac{1}{1+r-\delta} \right)^t \pi_t \quad (2)$$

where r is the equilibrium real interest rate and δ is the depreciation rate of capital (details follow).

Each period, an entrepreneur either has a filled job or a vacant position. The latter entails a per-period cost of $\eta > 0$ units of the consumption good.

Technology

The unit of production is a matched worker-entrepreneur pair. Unmatched agents come together via search. A constant returns to scale matching function determines the probability that a randomly-chosen entrepreneur with a vacancy meets a randomly-chosen unemployed. Specifically, the number of contacts per unit of time is given by

$$m(u_t, v_t) = M u_t^\kappa v_t^{1-\kappa} \quad (3)$$

where u is the number of unemployed persons and v is the measure of vacancies. Letting $\theta \equiv v/u$ denote labor market tightness, the job-filling probability is $q(\theta) = M\theta^{-\kappa}$ and the job-finding probability is $\theta q(\theta) = M\theta^{1-\kappa}$.

⁶As indicated in the opening section, the life-cycle structure is introduced in order to discipline the consumption-saving decisions of agents in the model.

⁷We use a logarithmic utility function for two reasons. First, a unit value is a natural benchmark for the range of empirically "plausible" coefficients of relative risk aversion (see Heathcote, Storesletten and Violante, 2009). Second, this coefficient implies a high elasticity of intertemporal substitution, which is consistent with the model period which we set to half a quarter (Subsection 3.1).

Once matched, a worker-entrepreneur pair produces a homogeneous consumption good. Production requires physical capital k and generates

$$f(k) = k^\alpha \quad (4)$$

units of output per period. Since production units are all identical, they employ the same levels of physical capital \tilde{k} . Physical capital depreciates at rate δ per period. Finally, a worker-entrepreneur pair is destroyed either by the retirement shock or, if the worker remains in the labor force at the end of a period, by an exogenous shock with per-period probability λ .

Incomplete asset markets

To diversify away idiosyncratic risk, individuals only have access to a single, risk-free asset which they can save but cannot borrow. The maximization of utility in (1) is hence subjected to a sequence of intertemporal budget constraints:

$$c_t + a_{t+1} \leq (1 + r - \delta) a_t + y_t^d \quad (5)$$

where a denotes assets holdings and y_t^d is disposable income at time t . Individuals do not have access to retirement plans: thus, $y_t^d = 0$ for those who have retired.

As in Krusell, Mukoyama and Şahin (2010), it is assumed that a is compounded from two types of assets: physical capital k and equity e . Equity e corresponds to a claim for the profits generated by entrepreneurs, including those with an unfilled position. Claims are held for the aggregate profit, not the profit of individual jobs (firms are jointly owned by workers), and the total amount of equity is normalized to one. Denoting the unit price of equity by p and the dividend paid to the holders of equity by d , a no-arbitrage condition between holding assets in the form of physical capital vs. equity implies:

$$\frac{p + d}{p} = 1 + r - \delta \quad (6)$$

The left hand-side in (6) is the return to buying one unit of equity at unit price p ; the right-hand side is the return to one unit of capital next period.⁸

Unemployment insurance

To mitigate the lack of perfect private insurance markets, the government runs an unemployment insurance system that stands similar to the current US system. It pays a constant amount of benefits b_1 for a definite period of time; after unemployment benefits have expired, individuals move on to social assistance which provides significantly lower benefits b_0 for an indefinite period of time.

⁸Notice that the budget constraints in (5) are implied by the no-arbitrage condition. Indeed, we have $c_t + k_{t+1} + pe_{t+1} \leq (1 + r - \delta)k_t + (p + d)e_t + y_t^d = (1 + r - \delta)(k_t + pe_t) + y_t^d$ after defining $a_t = k_t + pe_t$.

Anticipating on the experiments of Section 4, we also assume that unemployment benefit recipients can receive a lump-sum, up-front payment denoted by b_f .

The other difference between social assistance and unemployment benefits is that only the latter are subject to eligibility rules: an index $i \in \{0, 1\}$ indicates for each individual whether she qualifies for receiving unemployment benefits. For parsimony, exhaustion of and eligibility to unemployment benefits are modelled in a stochastic fashion. The eligibility status of an individual who is currently unemployed evolves according to a two-state Markov process:

$$p_{i,j} = \begin{bmatrix} 1 & 0 \\ p_0 & 1 - p_0 \end{bmatrix} \quad (7)$$

with $i, j \in \{0, 1\}$. That is, p_0 is the per-period probability of exhausting benefits (conditional on staying in the labor force). Afterward, an individual remains ineligible as long as she does not work. On the other hand, an individual who works and gets separated from the job at the end of the period (again, conditional on staying in the labor force) qualifies for unemployment benefits with probability p_e . Otherwise, she moves directly into social assistance.

The government finances unemployment insurance and social assistance programs jointly by means of a payroll contribution tax τ on wages. We use a payroll tax instead of the experience-rating system implemented in the US for two reasons. First, the one-worker-firm structure of the model does not allow accurate representation of experience-rating. Assuming a payroll tax, on the other hand, is standard in matching models. Second, Wang and Williamson (2002) report little aggregate effects of experience rating. Thus, this feature is unlikely to bring important insights into the effects of front-loading the benefit system.

2.2 Bellman equations

To formulate workers' and entrepreneurs' decision problems in recursive form, denote by R the value of being retired, U the value of unemployment and by W the value of being employed to the worker. For entrepreneurs, denote by J the value of having a filled job.

Beginning with retirees, their asset value solves the equation:

$$R(a) = \max_{a'} \{ \log(c) + \beta(1 - \zeta)R(a') \} \quad (8)$$

subject to

$$\begin{aligned} c + a' &\leq (1 + r - \delta)a \\ a' &\geq 0 \end{aligned}$$

For unemployed workers, there are two asset values indexed by the current eligibility status

$i \in \{0, 1\}$. These asset values are the solution to:

$$U_i(a) = \max_{a'} \left\{ \log(c) + \beta(1 - \sigma) \sum_{j=0,1} p_{i,j} (\theta q(\theta) W_j(a') + (1 - \theta q(\theta)) U_j(a')) + \beta \sigma R(a') \right\} \quad (9)$$

subject to

$$\begin{aligned} c + a' &\leq (1 + r - \delta)a + b_i \\ a' &\geq 0 \end{aligned}$$

Finally, for employed workers in their first period of employment, there are two asset values indexed by the eligibility status $i \in \{0, 1\}$ at the time of meeting the entrepreneur. Further, there is an asset value for subsequent periods of employment which we index by $i = +$. Hence:

$$W_i(a) = \max_{a'} \left\{ \log(c) + \beta(1 - \sigma) \left(\lambda \left(p_e U_1 \left(a' + \frac{b_f}{1 + r - \delta} \right) + (1 - p_e) U_0(a') \right) + (1 - \lambda) W_+(a') \right) + \beta \sigma R(a') \right\} \quad (10)$$

subject to

$$\begin{aligned} c + a' &\leq (1 + r - \delta)a + w_i(a) \\ a' &\geq 0 \end{aligned}$$

where $i \in \{0, 1, +\}$. In this budget constraint, $w_i(a)$ is the wage determined by a private bargain between the worker and the entrepreneur (see Subsection 2.3).

Associated with equation (8) is a decision rule for asset holdings $\bar{a}^R(a)$. Similarly, associated with equations (9) and (10) are a set of decisions rules for asset holdings $\bar{a}_0^U(a)$, $\bar{a}_1^U(a)$, and $\bar{a}_0^W(a)$, $\bar{a}_1^W(a)$, $\bar{a}_+^W(a)$, respectively.

Turning to entrepreneurs, there are three asset values indexed by the subscript $i \in \{0, 1, +\}$. Those depend on the wage $w_i(a)$ and hence on the asset holding decisions of the worker:

$$J_i(a) = \max_k \{f(k) - rk - (1 + \tau) w_i(a)\} + \frac{1 - \sigma}{1 + r - \delta} (1 - \lambda) J_+(a') \quad (11)$$

subject to the constraint: $a' = \bar{a}_i^W(a)$. This equation assumes that the value of a filled job is higher than the value of a vacancy, which holds true in equilibrium. Finally, the maximization problem in equation (11) implies:

$$r = \alpha \tilde{k}^{\alpha-1} \quad (12)$$

The last equation gives the optimal level of capital per production unit \tilde{k} .

2.3 Wage setting

Wages are set via Nash-bargaining, where the bargaining power of the worker is parametrized by $\phi \in (0, 1)$. Specifically, we posit a bargaining game that is supported by the take-it-or-leave-it interpretation of the generalized Nash product. We interpret ϕ as the probability that the worker makes a wage offer and assume that:⁹

- When the worker makes a wage offer, he/she demands the surplus $J_i(a) + W_i(a) - \tilde{U}(a)$ where $\tilde{U}(a)$ is the value of unemployed search. The worker therefore demands $\tilde{U}(a) + J_i(a) + W_i(a) - \tilde{U}(a) = J_i(a) + W_i(a)$ for all $i \in \{0, 1, +\}$.
- When the entrepreneur makes a wage offer, he/she provides the equivalent to the value $\tilde{U}(a)$. When $i \in \{0, 1\}$, $\tilde{U}(a) = U_i(a)$. On the other hand when $i = +$, rejection implies firing the worker and thus $\tilde{U}(a) = U_1\left(a + \frac{b_f}{1+r-\delta}\right)$.

As a result, the wage function $w_i(\cdot)$ indexed by $i \in \{0, 1\}$ is given by

$$w_i(a) = \arg \max_{\tilde{w}} \left\{ (W_i(a; \tilde{w}) - U_i(a))^\phi J_i(a; \tilde{w})^{1-\phi} \right\} \quad (13)$$

and the wage function when $i = +$ is given by

$$w_+(a) = \arg \max_{\tilde{w}} \left\{ \left(W_+(a; \tilde{w}) - U_1\left(a + \frac{b_f}{1+r-\delta}\right) \right)^\phi J_+(a; \tilde{w})^{1-\phi} \right\} \quad (14)$$

for all asset level a .

The assumptions above entail that bargained wages are not distorted by moral hazard problems: there is no shirking phenomenon that workers could exploit to bargain for higher wages. Following this logic, the Nash-bargained wages are also allowed to depend on the asset level of the worker. This is a matter of coherence more than one of realism as this ensures that the behavior of the worker-entrepreneur pair is not driven by unobserved savings.¹⁰

2.4 Equilibrium conditions

Agents take as given the interest rate, labor market tightness and the payroll tax rate. These are pinned down by the following equilibrium conditions.

Asset market clearing

The interest rate is pinned down by the asset market clearing condition. To this end, one needs to compute equilibrium dividends d , which is the sum of profits across active production units (the

⁹The outside option of the entrepreneur, i.e., the value of having a vacant position, is set equal to zero. This holds true in equilibrium due to the free entry condition (Subsection 2.4).

¹⁰Krusell, Mukoyama and Şahin (2010) discuss the realism of this assumption, as well as the relationship with individual rationality and commitment issues. As regards the results of the paper, we note in Subsection 3.2 that the assumption is innocuous because wages in the calibrated model turn out to be almost independent of assets.

population of which is denoted by $\mu_i^W(\cdot)$ net of total vacancy posting costs:

$$d = \sum_{i=0,1,+} \int_A \left(f(\tilde{k}) - r\tilde{k} - (1 + \tau) w_i(a) \right) d\mu_i^W(a) - \eta \theta u \quad (15)$$

The term under the integral sign corresponds to the per-period profit of firms and the last term makes use of the relationship $v = \theta u$.

Equilibrium dividends d and total asset holdings \bar{a} alongside the no-arbitrage equation (6) give the asset market clearing condition:

$$\bar{k} + \frac{d}{r - \delta} = \int_A a d\mu^R(a) + \sum_{i=0,1} \int_A a d\mu_i^U(a) + \sum_{i=0,1,+} \int_A a d\mu_i^W(a) \quad (16)$$

(where $\mu^R(\cdot)$ and $\mu_i^U(\cdot)$ are the population of retired and unemployed individuals, respectively). \bar{k} is capital aggregated across production units, which corresponds to \tilde{k} multiplied by total employment. The difference between the right-hand side and \bar{k} is $d/(r - \delta)$, the value of claims to the economy's firms.

Free entry

A free-entry condition holds for entrepreneurs in equilibrium: they exhaust the present discounted value of job creation net of the vacancy-posting cost. At the time of posting a vacancy, entrepreneurs observe the distribution of unemployed persons across asset levels; by the time of meeting workers, this distribution has evolved according to the law of motion of the economy. Thus, the free-entry condition reads:

$$\frac{\eta}{q(\theta)} = \frac{1}{1 + r - \delta} \sum_{i=0,1} \sum_{j=0,1} \int_A J_j(\bar{a}_i^U(a)) p_{i,j} (1 - \sigma) \frac{\mu_i^U(a)}{u} da \quad (17)$$

Since $\mu_i^U(a)$ is the beginning-of-period population of unemployed with asset level a and eligibility status i , the conditional distribution used to form expectations is obtained by scaling $\mu_i^U(\cdot)$ with the size of the unemployment pool u .

Balanced budget condition

Finally, the balanced budget condition of the government pins down the payroll tax through:

$$\tau \sum_{i=0,1,+} \int_A w_i(a) d\mu_i^W(a) = \sum_{i=0,1} b_i \int_A d\mu_i^U(a) + b_f \Omega \quad (18)$$

where Ω denotes the number of new entrants into the insured unemployment pool. This is given by $\Omega = p_e \lambda (1 - \sigma) \sum_{i=0,1,+} \int_A d\mu_i^W(a)$.

2.5 Equilibrium

Throughout the analysis, we focus on the recursive competitive equilibrium of the model. Such an equilibrium depends on the parametrization of the unemployment insurance system and is defined in a standard manner:

Definition. A competitive equilibrium is a set of decisions rules for asset holdings $(\bar{a}^R(a), \bar{a}_0^U(a), \bar{a}_1^U(a), \bar{a}_0^W(a), \bar{a}_1^W(a), \bar{a}_+^W(a))$, a list of wage functions $(w_0(a), w_1(a), w_+(a))$, a distribution of workers across assets and labor market status given by $(\mu^R(a), \mu_0^U(a), \mu_1^U(a), \mu_0^W(a), \mu_1^W(a), \mu_+^W(a))$, a value of labor market tightness θ and a tuple (τ, r) such that:

1. Workers optimize: Given $\theta, (\tau, r)$ and the wage functions $(w_0(a), w_1(a), w_+(a))$, the asset holding decisions $\bar{a}^R(a), \bar{a}_0^U(a), \bar{a}_1^U(a), \bar{a}_0^W(a), \bar{a}_1^W(a), \bar{a}_+^W(a)$ solve the inner maximization problem in the Bellman equation for retirees and workers.
2. Firms optimize: Given r , the optimal level of capital demanded by individual firms is \tilde{k} given by the first-order condition (12).
3. Wages are set via Nash bargaining: Given $\theta, (\tau, r)$ and the decisions rules for asset holdings $(\bar{a}^R(a), \bar{a}_0^U(a), \bar{a}_1^U(a), \bar{a}_0^W(a), \bar{a}_1^W(a), \bar{a}_+^W(a))$, the wage functions $w_0(a), w_1(a)$ and $w_+(a)$ are the solution to (13) and (14).
4. The markets clear: $\theta, (\tau, r)$ and the wage functions $(w_0(a), w_1(a), w_+(a))$ yield equilibrium dividends and a capital-labor ratio that are consistent with the employment and asset stocks implied by the distribution $(\mu^R(a), \mu_0^U(a), \mu_1^U(a), \mu_0^W(a), \mu_1^W(a), \mu_+^W(a))$ via equation (16).
5. The free-entry condition holds: Labor market tightness θ is pinned down by r , the asset holding decisions $\bar{a}_0^U(a)$ and $\bar{a}_1^U(a)$ and the distributions $\mu_0^U(a)$ and $\mu_1^U(a)$ via equation (17).
6. The budget is balanced: The payroll tax rate τ is determined by the wage functions $(w_0(a), w_1(a), w_+(a))$ and the distributions $\mu_0^U(a), \mu_1^U(a), \mu_0^W(a), \mu_1^W(a)$ and $\mu_+^W(a)$ in equation (18).
7. The distribution is time-invariant: $(\mu^R(a), \mu_0^U(a), \mu_1^U(a), \mu_0^W(a), \mu_1^W(a), \mu_+^W(a))$ is stationary for the set of decision rules $(\bar{a}^R(a), \bar{a}_0^U(a), \bar{a}_1^U(a), \bar{a}_0^W(a), \bar{a}_1^W(a), \bar{a}_+^W(a))$ and equilibrium tightness θ .

The law of motion for agents across the different states of the economy (condition (7) in the above definition) can be deduced from the Bellman equations (9) and (10) alongside the free-entry condition (17). Notice that the latter is written from the perspective of the beginning of period *after* newborn workers have entered the economy. We assume that: (i) the asset holdings of the dead are redistributed to newborn workers and (ii) that newborns are not entitled to collect unemployment insurance benefits.

3 Calibration and steady-state outcomes

This section describes the calibration and some outcomes of the benchmark economy ($b_f = 0$). We use US data to accord with the unemployment insurance system embedded in the model.

3.1 Calibration

The model period is chosen to be six weeks (half a quarter), as a compromise between computational costs and the short duration of unemployment spells in the US labor market. The length of the model period dictates a high elasticity of substitution, which aligns with the specification of the momentary utility function (see footnote 7). Next, using standard values from the real business cycles literature, the capital share α is set to 0.30 and the depreciation rate δ is set to 0.67 percent to obtain an investment-to-output ratio of 20 percent.

The probabilities σ and ζ are set equal to 0.0031 and 0.0081, respectively, to make the expected length of the working-life equal to 40 years and that of the retirement period equal to 15 years. The other sources of idiosyncratic risk in the model relate to transitions between employment and unemployment. Consistent with the long-run behavior of the US labor market, the targeted values is 45 percent for the job-finding and 3 percent for the job-separation rates (monthly). These values imply a target of 7 percent for the unemployment rate and a value of 0.0417 for the probability of job destruction conditional on staying in the labor force, λ , after adjusting to the model period and taking into account the life-cycle structure.

We use standard values and procedures from the search-matching literature to pin down values for the parameters κ , ϕ , M , and η . The elasticity of the job-filling rate with respect to labor-market tightness, κ , is set to 0.50; this is well within the range of estimates surveyed by Petrongolo and Pissarides (2001). The bargaining power of workers ϕ is set equal to κ to conform with the Hosios-Pissarides rule. Finally, the matching efficiency M is calibrated to the targeted job-finding rate and labor-market tightness θ is normalized to 1.0 to pin down the vacancy-posting cost η using the free entry condition. This procedure gives: $M = 0.5952$ and $\eta = 2.327$.

The remaining parameters pertain to the specification of unemployment insurance and social assistance programs. We use the following observations to select these parameters. First, figures from the OECD (2007) show that the replacement ratios of unemployment insurance and social insurance benefits in the United States are on average 45 and 5 percent, respectively. Setting $b_1 = 1.24$ and $b_0 = 0.14$ yield the same replacement ratio when compared to the average wage.¹¹ Second, the US insured unemployment rate is around one-third; we use this number to set the probability of gaining eligibility for benefits after job loss.¹² Finally, the probability of exhausting

¹¹The average wage is 2.728 in the benchmark economy. Notice that b_1 and b_0 influence wages, and thus that the calibration needs to look for values whose ratio to the average wage match the targeted replacement ratio.

¹²The insured unemployment rate is the ratio of the number of insured unemployed over the total number of unemployed. The figure of one-third is obtained by computing the fraction of unemployed workers who collected unemployment benefits in the (March) Current Population Surveys. This figure lines up well with empirical evidence from other data sources. For instance layoffs account for about a third of all separations in Job Opening and Labor Turnover Surveys; in most states, workers cannot claim unemployment benefits unless they have been laid off.

benefits p_0 is set to 0.2492 to make the (unconditional) expected duration of benefits equal to 26 weeks (4 model periods). After choosing this parameter, p_e is pinned down exactly by the targeted insured unemployment rate; this implies $p_e = 0.42$.

Heterogeneity in discount factors

Stochastic life-spans are instrumental in creating a high willingness to save, but the resulting wealth distribution does not have sufficiently many individuals who reside close to the borrowing constraint.¹³ The latter is potentially a concern because unemployment insurance is likely to be especially relevant for those with high marginal utilities from consumption. On the other hand, wealth-rich workers are of lesser interest because they need not rely on social safety nets to smooth out shocks to their earnings and employment status. Finally, in the model outlined in Section 2, it is not possible to determine how an individual's own difficulty to build up precautionary savings would influence his/her preference for publicly-provided insurance benefits.

We sidestep these problems by introducing heterogeneity in discount factors so as to force a fraction of agents to live with relatively few assets. Specifically, workers are assumed to be of two types: patient vs. impatient. Their respective discount factors are β_h and β_l and the share of impatient agents is denoted by ψ . The latter are identified to liquidity-constrained households; Zeldes (1989), and more recently Gorbachev (2011) estimate that they represent up to 20 percent of the US population, hence implying $\psi = 0.20$. The remaining 80 percent is meant to represent those whose savings drive the interest rate. Thus, the subjective discount factor β_h is set to 0.9951 to accord with an annualized interest rate of 4.0%. We choose $\beta_l = 0.9825$ to reproduce a very high annualized interest rate (15.0%). We gauge the implications of this parameter by studying the consumption path of the average impatient worker following job loss. Upon transiting into the unemployment insurance system, this worker reduces consumption by 8 percent. This, for instance, is the drop in consumption experienced by the insured unemployed in the Panel Study of Income Dynamics studied by Gruber (1997).

3.2 Key model outcomes

Table 1 summarizes the parameter values used for the benchmark economy. Before proceeding with the numerical experiments, we comment on some outcomes implied by these values.

The upper graphs in Figure 1 report a firms' asset value of meeting an unemployed worker. This asset value is a function of the eligibility status and current asset level of the worker because wages are allowed to depend on these characteristics. Meanwhile, most of the heterogeneity in these values accrues from the eligibility status, not from asset holdings: we find that wages are flat

¹³Another difference between the distribution of wealth in the model and those typically observed in the data is that the former displays relatively little dispersion. The reason is that the only source of differences between agents after they enter the labor market is through their idiosyncratic employment trajectories. We considered a version of the model with three populations of agents with different discount factors in order to improve the fit to the wealth distribution. The results obtained were similar to those reported in the paper. We reverted to the impatient/patient specification of the model for clarity of exposition.

Table 1. Parameter values (one model period is half a quarter)

<i>Demographics and preferences</i>	
Share of impatient workers	$\psi = 0.20$
Subjective discount factor, patient	$\beta_h = 0.9951$
Subjective discount factor, impatient	$\beta_l = 0.9825$
Probability of retiring	$\sigma = 0.0031$
Probability of dying	$\zeta = 0.0083$
<i>Technology</i>	
Capital share	$\alpha = 0.30$
Depreciation rate of capital	$\delta = 0.0067$
<i>Matching frictions</i>	
Probability of job separation	$\lambda = 0.0417$
Efficiency of the matching function	$M = 0.5952$
Elasticity of the job-filling rate	$\kappa = 0.50$
Bargaining power of workers	$\phi = 0.50$
Unit cost of vacancy creation	$\eta = 2.327$
<i>Government-mandated programs</i>	
Unemployment insurance benefits	$b_1 = 1.24$
Social assistance benefits	$b_0 = 0.14$
Probability of gaining eligibility	$p_e = 0.42$
Probability of exhausting benefits	$p_0 = 0.2492$

for most asset levels.¹⁴ Thus, although agents are allowed to contract upon the asset level of the worker, the effect of asset on wages does not constitute too strong a motive for workers to accumulate more financial wealth. On the other hand, unemployment insurance benefits strengthens the hand of unemployed workers upon meeting with an entrepreneur. In the presence of random search, this has a negative effect on vacancy creation.

The lower graphs in Figure 1 plot the net-savings decisions of workers.¹⁵ Employed workers accumulate assets to self-insure against unemployment risk and the unemployed run down their financial wealth. The insured unemployed adopt a more mixed strategy as their asset holdings approach the borrowing constraint: the poorest prefer to save their unemployment benefits in anticipation of a transition through social assistance. Finally, high- β workers have much more savings than low- β workers, as the graphs suggest. The average level of assets among high- β workers is 123 units, which amounts to about 6 years of yearly income. Among low- β workers, this figure shrinks to 80 percent of yearly income. Thus, the heterogeneity in discount factor induces a vast heterogeneity of situations with regards the ability the ability to build up savings.

¹⁴A similar outcome obtains in Krusell, Mukoyama and Şahin (2010). Wages increase with assets in a concave fashion (inherited from the utility function) because the difference between the asset values of employment and unemployment decreases with consumption, and thereby assets, and the curve flattens quickly.

¹⁵A dimension of heterogeneity that is masked on the graphs is that workers hired from the pool of uninsured unemployment suffer a lower wage in their first period of employment (as per the Nash-bargaining game; see Subsection 2.3). These workers, however, account for a small share of total employment (about 1 percent) and their behavior is of little importance for equilibrium allocations. Thus, instead of reporting two curves for employed workers, a single curve is constructed by averaging over asset levels. The same procedure is used for the graphs in Figure 2.

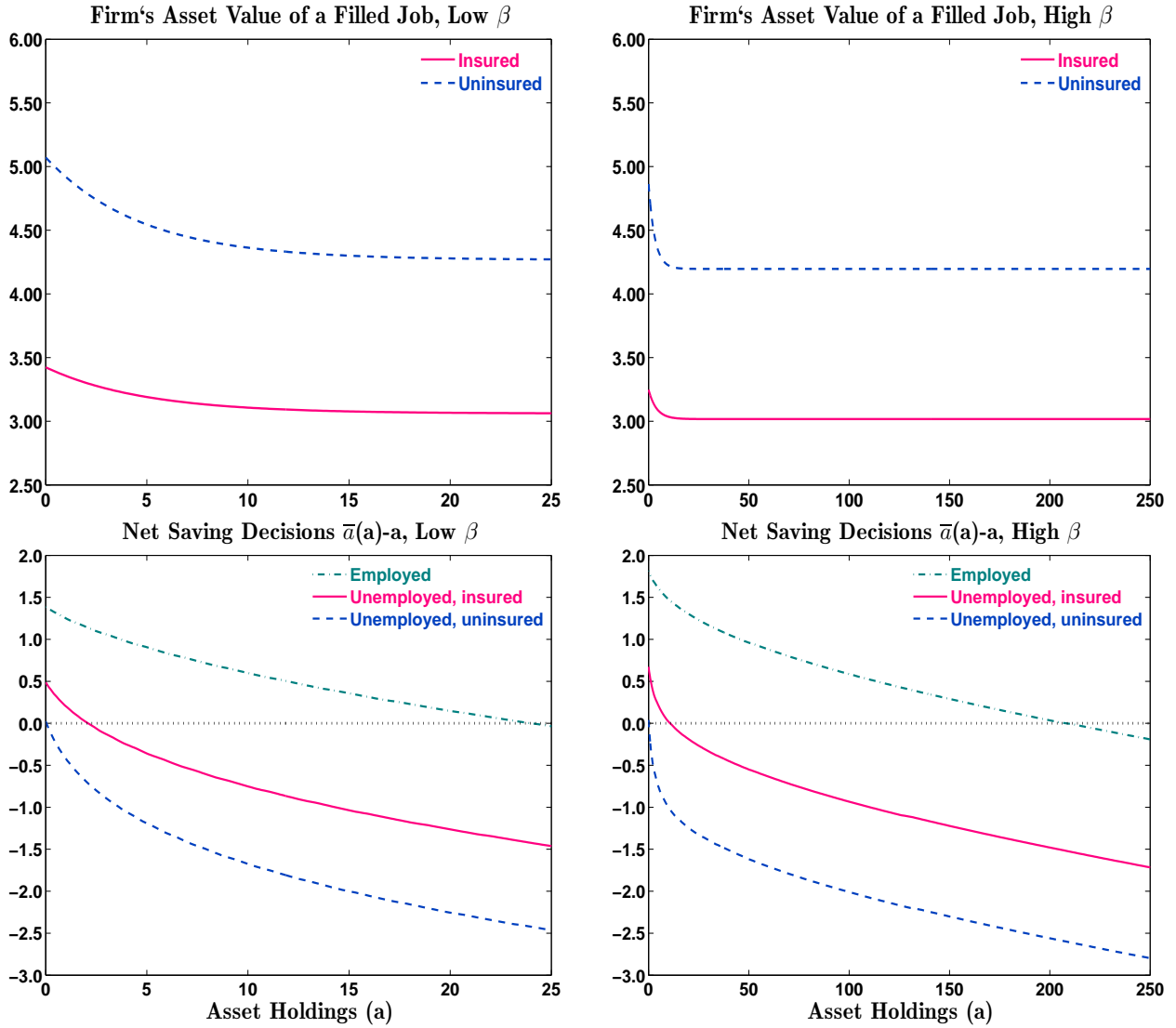


Figure 1. Selected outcomes of the benchmark economy

NOTE: The upper graphs plot a firm's asset value of filling a vacant job. The lower graphs plot the policy functions for net savings $\bar{a}(a) - a$. The scale on the x-axis is different for the left and right graphs since the plots are shown for the relevant range of asset levels only.

4 Quantitative effects of front-loading the benefit system

This section discusses the effects of front-loading the benefit system in the benchmark economy parametrized to current US unemployment policies.

4.1 Preliminaries

In the benchmark economy ($b_f = 0$), the unemployment insurance system yields an expected discounted cumulative payment of:

$$\sum_{t=0}^{+\infty} \zeta^t b_1 = \frac{1}{1 - \zeta} b_1 \quad (19)$$

where $\zeta = \frac{(1-\sigma)(1-p_0)}{1+r-\delta}$ is the per-period probability of maintaining benefits multiplied by the discount factor. Front-loading the benefit system consists in making future payments of benefits available immediately upon job loss. Denoting by \tilde{b}_f the up-front benefit and by \tilde{b}_1 the benefit paid on a regular basis, the expected discounted cumulative value of an alternative scheme is¹⁶

$$\tilde{b}_f + \sum_{t=0}^{+\infty} \zeta^t \tilde{b}_1 = \tilde{b}_f + \frac{1}{1-\zeta} \tilde{b}_1 \quad (20)$$

The crux of the experiment is to compare equilibrium allocation and welfare in economies where the bundle $(\tilde{b}_1, \tilde{b}_f)$ provides the same expected discounted cumulative payment as under the US baseline scenario.

Hereafter, we refer to the fraction of benefits that are front-loaded. This corresponds to

$$\frac{1 - \tilde{b}_1/b_1}{1 - b_0/b_1} (\times 100) \quad (21)$$

The numerator $1 - \tilde{b}_1/b_1$ measures the fraction of benefits that are being paid up-front relative to the benchmark system. The denominator adjusts for the fact that, in the experiments, we do not consider cases where \tilde{b}_1 becomes lower than b_0 since workers would then prefer to move into social assistance after collecting \tilde{b}_f . With the above definition, a percentage of a 100 percent indicates that constant unemployment benefits \tilde{b}_1 have been shrunk to the value of social assistance benefits.

Welfare criteria

The welfare comparisons drawn in the experiments are based on a standard compensated variation measure: we tabulate the value of ϑ such that

$$\mathbb{E}_0 \langle V((1 + \vartheta)(c_0, c_1, \dots)) \rangle = \mathbb{E}_0 \langle V(\tilde{c}_0, \tilde{c}_1, \dots) \rangle \quad (22)$$

where: $V(\cdot)$ is the lifetime utility of an agent defined over his/her sequence of consumption streams, c_0, c_1, \dots denote consumption streams in the benchmark economy and $\tilde{c}_0, \tilde{c}_1, \dots$ the consumption streams in an equilibrium obtained with a different scheme for unemployment benefits.

The welfare measure ϑ can be computed for each individual worker with his/her own asset holdings, employment status and discount factor. To provide synthetic welfare criteria, the individual ϑ 's can then be averaged using the stationary distribution of the benchmark economy. The resulting figure is hence the average welfare effect of moving each individual agent from the benchmark economy into the equilibrium where a different unemployment insurance scheme leads to a different set of equilibrium prices. More precisely, we base our discussion of welfare effects on the following two measurements:

¹⁶Observe that ζ is an endogenous object. That is, when looking for the value \tilde{b}_f that yields the same cumulative payment as in (19), one needs to solve for the interest rate after each update of \tilde{b}_f when computing the equilibrium. We obtain virtually the same results when ζ remains fixed to an exogenous value throughout the numerical experiment. These results are available upon request.

- Changes in welfare for new entrants into the benefit system. This is an informative, yet only partial-equilibrium effect; we label this criterion “Welfare, New entrants”.
- Changes in welfare averaged across all workers; this measures the general equilibrium effect and we label this criterion “Welfare, Aggregate”.

The motivation for using several welfare criteria is twofold. First, the lifetime utility of new entrants into the benefits system is what best captures the trade off between insurance at long unemployment durations vs. smooth consumption upon job loss. Second, the overall welfare figure is sometimes difficult to interpret because it aggregates across heterogeneous agents. The welfare criterion for new entrants helps understand the aggregate welfare figure, as the discussion in the next subsections illustrate.

A final remark concerns the transition dynamics between steady-states, which is not taken into account by these two welfare criteria. The full transition path in this model depends on multiple effects that are not the focus of the paper; see Mukoyama (2013) for a complete discussion in a similar environment. Another, more fundamental reason is that the first-order determinants of the transition path are likely to depend on the political economy of front-loading the benefit system. For instance the outcomes may differ drastically depending on whether changes apply only to new entrants into unemployment insurance or also to on-going benefit recipients. These are key issues for the policy change, which would deserve a study in its own right.

4.2 Benchmark results

Table 2 contains the main results discussed in this section. The first column corresponds to the benchmark economy while the other columns characterize equilibria where the amount of benefits that are paid up front is gradually increased. In column (VI) for instance, unemployed workers who qualify for benefits receive the whole cumulative payment initially, after which their flow income until finding a job is the same as under social assistance.

In the presence of matching frictions, front-loading the payment of benefits instead of providing them on a regular basis reduces the pressure on equilibrium wages. A 1.4 percent reduction in the average wage in turn contributes to a 0.3 percentage point decline in unemployment and to an increase in vacancy posting by 4.6 percent. The magnitude of these labor market effects seems plausible: vacancy posting is the margin that affects labor market dynamics in this model, unemployment benefits have limited size and duration and only a fraction of the unemployed collect these benefits. Finally, the payroll tax required to finance the provision of benefits increases slightly. This is the product of several countervailing forces. Higher employment rates enlarge the tax base, but they also imply lower average wage and a larger inflow of newly unemployed workers who collect the payment of their unemployment benefits up front.

Front-loading the benefit system increases employment and gross output; that is, the sum of output across active production units. However, since firms increase vacancy posting, more output is destroyed in the form of job-creation costs. As a result, net output (hence consumption) de-

Table 2. Quantitative effects of front-loading the benefit system: Benchmark economy

% of benefits front-loaded	0	20	40	60	80	100
	(I)	(II)	(III)	(IV)	(V)	(VI)
Tax rate τ (%)	1.39	1.75	2.08	2.44	2.81	3.21
Up-front benefit \tilde{b}_f	0.00 w	0.32 w	0.65 w	0.98 w	1.31 w	1.64 w
<i>Equilibrium:</i>						
Unemployment (%)	7.00	6.95	6.89	6.84	6.78	6.72
Average wage w	100.00	99.70	99.41	99.14	98.88	98.63
Assets	100.00	99.64	99.28	98.91	98.53	98.14
Consumption	100.00	99.93	99.85	99.78	99.70	99.62
<i>Welfare, New entrants:</i>						
Average, low β	100.00	100.24	100.49	100.76	101.04	101.33
Average, high β	100.00	100.06	100.12	100.17	100.22	100.27
Poorest, low β	100.00	101.02	101.90	102.67	103.33	103.89
Poorest, high β	100.00	100.36	100.67	100.95	101.21	101.45
<i>Welfare, Aggregate:</i>						
Average, low β	100.00	100.04	100.09	100.15	100.21	100.28
Average, high β	100.00	100.01	100.02	100.02	100.03	100.03
Average	100.00	100.02	100.03	100.05	100.06	100.08

NOTE: Statistics without meaningful units of measurement (wage, assets and consumption) are normalized to 100.0 in the steady-state equilibrium of the benchmark economy. Welfare effects (defined in equation (22)) are expressed in percentage points; they measure changes relative to the benchmark economy of column (I).

creases as one moves towards the right columns of the table. Consumption is also less volatile in this part of the table since front-loading the payment of unemployment benefits improves insurance upon job loss, as discussed momentarily. It follows that precautionary savings and therefore asset supply decrease when the fraction of benefits that are paid up front increases.

Effects on welfare

To highlight the mechanisms at play, in Table 2 we report the welfare change for new benefit recipients on average and also among the poorest workers in the economy. By construction, these figures are biased in favor of the policy change. First, the difference between agents' subjective discount rate and the net interest rate implies that they prefer receiving their benefits up front. Second, very few employed workers reside close to the borrowing constraint. With this qualification in mind, we note that averaging across new benefit recipients (the average values reported in the panel "Welfare, New entrants") also indicates a substantial improvement. The welfare gain for low- β and high- β benefit recipients is 1.3 and 0.3 percent, respectively.

It is useful to decompose the welfare change for new entrants into the benefit system into two components: (i) the effect of shrinking the constant flow benefit from b_1 to b_0 and (ii) the effect of collecting the up-front benefit b_f . The results are displayed in the graphs of Figure 2, where the dashed line and the dashed-dotted line plot the effects of (i) and (ii), respectively; the solid line corresponds to the effect labeled "Welfare, New entrants".

For most asset levels (expressed relative to annual earnings), Figure 2 shows that the welfare

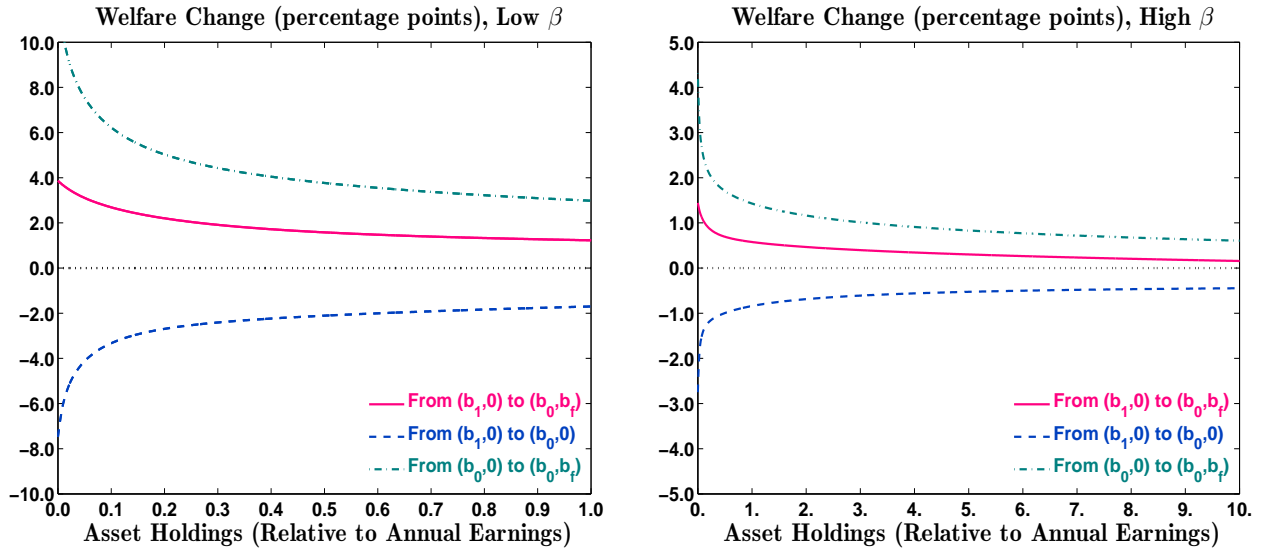


Figure 2. Welfare effects (for new benefit recipients) of front-loading the benefit system

NOTE: The percentage of benefits front-loaded is 100 percent (column (VI) in Table 2). The solid line shows the effect of moving from the bundle $(b_1, 0)$ to (b_0, b_f) . The dashed line shows the effect of moving from $(b_1, 0)$ to $(b_0, 0)$. The dashed-dotted line shows the effect of moving from $(b_0, 0)$ to (b_0, b_f) . On the x-axis, assets are measured with respect to annual earnings; the scale on the x-axis is different for the left and right graphs since the plots are shown for the relevant range of asset levels only. On the y-axis, welfare effects are expressed in percentage points; the scale on the y-axis is different for the left and right graphs since the magnitude of welfare effects differs across agents.

losses from shrinking unemployment benefits are nonnegligible: the average effect is -1.8 (resp. -0.5) percent of lifetime consumption for low- β (resp. high- β) workers. This is more than compensated by the effects of collecting the up-front benefit b_f , as this implies an average welfare increase of 3.2 (resp. 0.8) percent when moving from the $(b_0, 0)$ scheme to the (b_0, b_f) scheme. Thus, the experiment captures the trade-off between providing means to sustain consumption at long unemployment durations vs. providing insurance against job loss while letting workers decide on how to allocate consumption in subsequent periods.

The bottom panel of Table 2 reports the welfare change on average among low- β and high- β workers, and finally the average of these two figures. These numbers are lower than the average welfare change for new benefit recipients; this indicates that front-loading the benefits system produces also some negative welfare effects, which are discussed in the next paragraphs. Nevertheless, the result is that this simple redesign of the payment scheme increases aggregate welfare: the overall gain is a 0.08 percent of lifetime consumption. The increase is particularly large for those individuals who face more difficulties to build up savings (low- β workers) as the gain reaches 0.28 percent of their lifetime consumption.

To provide some perspective on the results, we note that the welfare-maximizing level of unemployment benefits yields a welfare gain of 0.12 percent in the study by Krusell, Mukoyama and Şahin (2010). There are differences between theirs and the model analyzed here: for instance, they consider a constant unemployment benefit of indefinite duration. Most importantly, they find that this welfare gain is achieved by cutting unemployment benefits by 75 percent. The experiment we

study comes close to replicating the same welfare gain while leaving the expected cumulative sum of benefits unchanged relative to baseline. Thus, there are substantial welfare implications from varying the payment of unemployment benefits in this incomplete market setting.

Role of general equilibrium variables

We perform a decomposition exercise to gain insights into the welfare figures just discussed. Specifically, we introduce the consecutive adjustments that correspond to moving from the first to the last column of Table 2 and measure the lifetime utilities associated with each adjustment. That is, we start by front-loading the payment of unemployment benefits (i.e., we set b_1 to b_0 and set b_f to the value calculated in column (VI) of Table 2). Then we adjust θ , followed by r , and finally τ to the values computed in the new environment.¹⁷ Finally, using the sequence of partially adjusted lifetime utilities, we tabulate the welfare change associated with each adjustment towards the new steady-state equilibrium.¹⁸

Table 3 reports the results of the decomposition exercise.¹⁹ For both impatient and patient workers, the welfare improvement from front-loading the benefit system is large, ranging from 1.0 to 2.0 percent of lifetime consumption when measured among new benefit recipients and 0.6 to 0.9 percent when computed in the aggregate. The increase in the job-finding rate (higher labor market tightness) yields a further increase in welfare: the order of magnitude is 0.2 percent of lifetime consumption on average. This indirect effect is about a third of the improvement brought by the direct effect of front-loading the benefit system. Eventually, the interest rate decreases slightly, which reduces welfare by making self-insurance more costly.²⁰ The main welfare loss occurs through the upward adjustment of the payroll tax. Moving from columns (III) to (IV), we find that the magnitude of the welfare loss in the aggregate is larger than the welfare gain of moving from the benchmark to column (I). This is masked in the first welfare criterion since the burden of

¹⁷The exercise captures the effect of each adjustment only partially since, for instance, equilibrium tightness in the new steady-state incorporates the effects of a change in the interest rate and the payroll tax.

¹⁸For each adjustment, we measure lifetime utility after renegotiation of the wage. Alternatively, we could report the effect of a change in, say, θ before and after renegotiation of the wage. These before/after effects turn out to be quantitatively small. Our choice to report only the “after” effect is guided by the fact that the change in τ affects workers only through renegotiation of the wage.

¹⁹Notice that the sum of the partial-equilibrium welfare effects (column (V) of Table 3) does not exactly match the corresponding figure in column (VI) of Table 2. This is because summing the partial-equilibrium changes in lifetime consumption gives only a first-order approximation of the overall change. To understand this, consider the measurement of a change in lifetime utility from V_0 to V_2 and denote by $\vartheta_{0,2}$ the compensated variation measure. With logarithmic utility (and since workers derive utility from consumption only), we have

$$\log(1 + \vartheta_{0,2}) = (1 - \beta)(V_2 - V_0)$$

Next, if there is an intermediary adjustment with associated lifetime utility V_1 , then we can also write $V_2 - V_0 = V_2 - V_1 + V_1 - V_0$. Accordingly, $\vartheta_{0,1}$ and $\vartheta_{1,2}$ can be computed by applying the above formula. It follows that

$$(1 + \vartheta_{0,2}) = (1 + \vartheta_{0,1})(1 + \vartheta_{1,2})$$

Thus, $\vartheta_{0,2} \approx \vartheta_{0,1} + \vartheta_{1,2}$ is valid only as a first-order approximation. Comparing column (V) in Table 3 with column (VI) in Table 2, we see that the approximation is accurate (the order of magnitude of the difference is 0.01). This is explained by the fact that welfare effects are typically small in magnitude.

²⁰The cost is measured by the difference between an individual’s subjective discount rate and the real interest rate.

Table 3. Front-loading the benefit system: Partial- and General-equilibrium effects

	Effect of front-loading (I)	Effect of θ (II)	Effect of r (III)	Effect of τ (IV)	Total (V)
<i>Welfare, New-entrants:</i>					
Average, low β	2.06 [1.54]	0.55 [0.41]	0.12 [0.09]	-1.37 [-1.02]	1.34
Average, high β	0.99 [3.51]	0.31 [1.09]	-0.09 [-0.33]	-0.91 [-3.24]	0.28
Average	1.21 [2.44]	0.36 [0.72]	-0.05 [-0.10]	-1.01 [-2.04]	0.49
<i>Welfare, Aggregate:</i>					
Average, low β	0.86 [3.54]	0.33 [1.37]	0.09 [0.38]	-1.03 [-4.24]	0.24
Average, high β	0.56 [28.78]	0.20 [10.54]	-0.07 [-3.40]	-0.67 [-34.63]	0.02
Average	0.62 [9.68]	0.23 [3.60]	-0.03 [-0.54]	-0.74 [-11.63]	0.06

NOTE: An entry in the table is the welfare effect of the adjustment indicated at the top of each column. Welfare effects (defined in equation (22)) are expressed in percentage points. In column (V), an entry is the sum of the welfare effects in columns (I)–(IV). The numbers in square brackets is the ratio between the welfare effect in the column and the total welfare effect reported in column (V).

adjusting the tax rate is borne by employed workers.²¹ Finally, summing the changes associated with these consecutive adjustments yields an overall positive welfare effect: the sum of the direct and indirect welfare gain offsets the loss that occurs through the tax increase.

4.3 Varying the cumulative sum of benefit payments

Although the focus is on varying unemployment benefits by duration while keeping the cumulative sum unchanged, it is also informative to change the baseline scenario and repeat the experiment. Two parameters determine the value of the cumulative sum of benefit payments: the generosity and duration of unemployment benefits. In this subsection, we comment briefly on the effects of introducing large variations in these two parameters (50 percent deviations below and above their baseline value). The results are reported in Table B1 of the Appendix.

Changes in the generosity and duration of unemployment benefits confirm the equilibrium effects of front-loading the benefit system discussed in the benchmark experiment. A comparison of the welfare figures also aligns with the main results: we obtain lower (resp. higher) welfare effects when the generosity or the duration is reduced (resp. increased). Thus, these experiments show that the results are robust to changing the baseline scenario.

The more interesting result pertains to the comparison of changing the generosity vs. changing the duration of unemployment benefits. Intuition suggests that, since most jobless spells end

²¹That is, the welfare change in employment is significantly discounted under the first welfare criterion since it measures welfare from the perspective of individuals whose immediate future is an unemployment spell.

Table 4. Quantitative effects of front-loading the benefit system: No eligibility restriction

% of benefits front-loaded	0	20	40	60	80	100
	(I)	(II)	(III)	(IV)	(V)	(VI)
Tax rate τ (%)	2.79	3.64	4.51	5.42	6.36	7.33
Up-front benefit \tilde{b}_f	0.00 w	0.33 w	0.65 w	0.99 w	1.33 w	1.67 w
<i>Equilibrium:</i>						
Unemployment (%)	7.00	6.86	6.72	6.58	6.44	6.31
Average wage w	100.00	99.44	98.81	98.09	97.30	96.42
Assets	100.00	99.46	98.91	98.33	97.73	97.11
Consumption	100.00	99.97	99.94	99.91	99.88	99.84
<i>Welfare, New entrants:</i>						
Average, low β	100.00	100.37	100.74	101.12	101.51	101.90
Average, high β	100.00	100.05	100.10	100.15	100.19	100.22
Poorest, low β	100.00	101.19	102.23	103.14	103.94	104.61
Poorest, high β	100.00	100.41	100.77	101.09	101.39	101.65
<i>Welfare, Aggregate:</i>						
Average, low β	100.00	100.09	100.18	100.28	100.37	100.47
Average, high β	100.00	99.99	99.98	99.97	99.95	99.93
Average	100.00	100.01	100.02	100.03	100.03	100.04

NOTE: Statistics without meaningful units of measurement (wage, assets and consumption) are normalized to 100.0 in the steady-state equilibrium of the benchmark economy. Welfare effects (defined in equation (22)) are expressed in percentage points; they measure changes relative to the benchmark economy of column (I).

before unemployment benefits expire, increasing the duration of benefits is of little relevance in the benchmark economy. That is, the risk of long-term unemployment is second order. It follows that front-loading the benefit system should improve workers' welfare more under this scenario by giving them access to benefits that usually they do not collect. This insight is confirmed by the numerical experiments. Front-loading benefits with duration equal to 9 months (vs. 6 months in the baseline) yields a welfare gain in the aggregate of 0.17 percent of lifetime consumption. For comparison, when the replacement ratio of unemployment benefits is set to 60 percent (vs. 45 percent in the baseline), the welfare gain of front-loading the benefit system is "only" 0.08 percent.

4.4 Varying eligibility for unemployment benefits

Due to the welfare loss associated with the tax increase, one can conjecture that front-loading the payment of unemployment benefits is especially costly under a lenient unemployment insurance system. To verify this, we repeat the experiment after setting the probability of gaining eligibility for benefits p^e equal to one.²² That is, all separated workers can collect unemployment benefits (conditional on staying in the labor force). The results are reported in Table 4.

When all separated workers are eligible for unemployment benefits, the labor market effects of

²²Unlike the previous subsection, in this experiment the cumulative sum of unemployment benefits remains unchanged relative to the baseline scenario (except for a change in the interest rate, but this has negligible effects). Thus, in column (I) of Table 4, after changing p^e we also recalibrate η to make the unemployment rate match the target of 7 percent. This implies $\eta = 2.081$.

front-loading the benefit system are amplified. Specifically, the decrease in the unemployment rate is 0.7 percentage point (vs. 0.3 in the benchmark experiment), the payroll tax rises from 2.8 to 7.3 percent and the average wage declines by more than 3 percentage points. High- β workers (who make up for 80 percent of the population) bear the bulk of the adjustment cost: welfare on average among them decreases by 0.07 percent of lifetime consumption. Meanwhile, relative to the benchmark experiment, we find a slightly larger welfare increase for low- β workers, i.e., nearly half a percent of lifetime consumption. Averaging these numbers, the welfare change associated with front-loading the benefit system is positive but twice lower than under the baseline. The results we obtain in the benchmark economy are thus not overturned by increasing the probability of eligibility to one. Nevertheless, this experiment shows that front-loading the payment of unemployment benefits is not fraught with problems when provision is unmonitored: significant welfare losses may result as a consequence of the increased spending on unemployment insurance.

5 Does the nature of labor market frictions matter?

The previous section revealed non-trivial welfare effects of front-loading the benefit system. In this section, we examine the relationship between this result and the assumption that labor market frictions are subsumed by a Mortensen-Pissarides matching function. To this end, we consider an alternative model with costly search efforts as the source of labor market frictions.

While there exist other ways of modelling frictions, the search-effort construct is appealing because it takes the opposing view of the matching function. Indeed, in the model of Section 2, there is a unique job-finding rate which is taken as given by the unemployed. In the model analyzed in this section, an unemployed chooses his/her probability to gain employment and this results in significant cross-sectional heterogeneity in job-finding rates.

5.1 Setup for comparison

We construct and evaluate a search effort model similar to Wang and Williamson (2002) and Young (2004).²³ For brevity, the description is trimmed in this subsection to contain only an outline of the model. A complete formal description is provided in Appendix A.

Individual preferences

To introduce costly search effort, the problem of workers is replaced by the maximization of

$$\mathbb{E}_0 \sum_{t=0}^{+\infty} \beta^t \left[\log(c_t) + A \frac{(1-s_t)^\gamma - 1}{\gamma} \right] \quad (23)$$

²³As noted in the review of literature section, we cannot draw directly on the experiments of Wang and Williamson (2002) and Young (2004) since they do not consider the effects of front-loading the benefit system. These authors study the effects of constant unemployment benefits in light of the trade-off between consumption smoothing and moral hazard problems. They also consider job retention efforts of the employed, while we abstract from this margin to maintain symmetry between the search effort model and the matching model of Section 2.

$A > 0$ and $\gamma > -1$ are two constants that parametrize the disutility of search efforts. Search efforts s lie between zero and one and are unobservable by the government (there is no monitoring).

Search frictions

For individuals who are currently unemployed, search efforts map into the probability of moving into work (conditional on staying in the labor force) via

$$\pi(s) = s^\xi \tag{24}$$

where $\xi \in [0, 1]$ to make the probability increasing and concave in search effort.²⁴ On the other hand, individuals who are currently employed and those who have retired cannot control their probability of working in the subsequent period; job destruction and retirement shocks are purely exogenous. As a result, it is optimal for them to exert zero search effort.

Other features

The search effort model is best described as having one centralized labor market that workers join and leave randomly. Production is by a representative firm that uses a production function analogous to equation (4). The firm operates competitively and there is a single wage level pinned down by marginal product conditions. In turn, since there is only one wage level, b_1 , b_0 and b_f can be specified as “true” replacement ratios: i.e., the income they provide is equal to $b_i w$ where w is the equilibrium wage. It follows that the budget constraint of the government depends on the distribution of workers across employment and unemployment, but not on the wage level.

In the search effort model too, we focus on recursive competitive equilibrium. Such an equilibrium is defined as in Section 2.5: (i) workers take prices functions as given and optimize their behavior, (ii) the representative firm optimizes too, (iii) the markets clear, (iv) the government balances its budget, and (v) the distribution of agents implied by optimal decisions is time-invariant.²⁵

Calibration

We can assign the same values to those parameters that describe demographics, preferences and technology in Table 1 (they achieve similar calibration targets). The value of the job destruction probability λ is also the same as in the matching model since workers never quit into unemployment. There remains to calibrate ξ , γ and A , alongside the unemployment insurance system.

We follow Alvarez and Veracierto (2001) and set the elasticity of the search technology, ξ , equal to γ to simplify the computation of search efforts. γ is disciplined with what is often interpreted as evidence of moral hazard, namely the (partial equilibrium) elasticity of unemployment

²⁴Observe that since $\pi(1) = 1$, the duration of an unemployment spell in the search effort model cannot be attributed to a lack of employment opportunities (unlike in the matching model).

²⁵Notice that, since the model embodies a representative firm instead of a continuum of entrepreneurs, a competitive equilibrium is simplified in that there is no wage bargaining and the employment level is pinned down by the search efforts of the unemployed.

Table 5. Quantitative effects of front-loading the benefit system: Search effort model

% of benefits front-loaded	0	20	40	60	80	100
	(I)	(II)	(III)	(IV)	(V)	(VI)
Tax rate τ (%)	1.38	1.41	1.49	1.63	1.84	2.11
Up-front benefit \tilde{b}_f	0.00 w	0.32 w	0.64 w	0.97 w	1.29 w	1.62 w
<i>Equilibrium:</i>						
Unemployment (%)	7.00	6.54	6.20	5.94	5.75	5.66
Wage w	100.00	99.95	99.85	99.70	99.49	99.23
Assets	100.00	100.42	100.76	101.02	101.19	101.29
Consumption	100.00	100.46	100.83	101.11	101.30	101.39
<i>Welfare, New entrants:</i>						
Average, low β	100.00	100.38	100.75	101.13	101.50	101.87
Average, high β	100.00	100.17	100.33	100.46	100.59	100.69
Poorest, low β	100.07	101.19	102.21	103.11	103.88	104.54
Poorest, high β	100.03	100.57	101.05	101.47	101.83	102.13
<i>Welfare, Aggregate:</i>						
Average, low β	100.00	100.06	100.11	100.13	100.13	100.11
Average, high β	100.00	100.06	100.10	100.13	100.14	100.13
Average	100.00	100.06	100.10	100.13	100.14	100.13

NOTE: Statistics without meaningful units of measurement (wage, assets and consumption) are normalized to 100.0 in the steady-state equilibrium of the benchmark economy. Welfare effects (defined in equation (22)) are expressed in percentage points; they measure changes relative to the benchmark economy of column (I).

durations with respect to the generosity of benefits. Numerous studies reviewed in Krueger and Meyer (2002) find this elasticity to be around 0.5. Thus, we calibrate γ and A to match this elasticity together with an unemployment rate of 7 percent. This yields $\gamma = 0.98$ and $A = 12.5$.

As just noted, b_1 and b_0 can be parametrized directly as replacement ratios in the search effort model; in the baseline scenario ($b_f = 0$) they are set to 0.45 and 0.05, respectively. The probability of exhausting benefits p_0 is 0.2492, as in the matching model. The eligibility probability p_e , on the other hand, has to be calibrated jointly with γ and A to obtain the targeted insured unemployment rate. This is achieved with $p_e = 0.27$.

5.2 Quantitative effects

Table 5 reports the effects of front-loading the benefit system in the search effort model. Beginning with changes in equilibrium allocations, we find a significantly larger increase in re-employment rates. Indeed, when constant benefits shrink, the insured unemployed exert more search efforts and the unemployment rate declines by up to 1.4 percentage points.²⁶ The capital-labor ratio also diminishes, which results in a decrease of the equilibrium wage by 0.8 percent. The consumption figures show that the increase in employment more than compensates for lower capital-labor ratios: output actually increases as one moves towards the right columns of Table 5. The large increase in

²⁶There is, of course, a large heterogeneity in the underlying job-finding rate: observe for instance that newly separated workers who qualify for benefits in column (VI) will exert almost no search effort initially as they enter the unemployment pool with a lump-sum transfer of almost 2.5 monthly wages (1.6 semi-quarterly wages).

output (1.4 percent) is a consequence of total labor input being determined by the privately-optimal search efforts of the unemployed.

Turning to the welfare effects, front-loading the benefit system in the search effort model results in welfare gains that are similar in magnitude to those computed in the matching model. This is despite the increase in aggregate consumption. To understand this, notice that it takes a very large disutility of search efforts to replicate the elasticity of unemployment durations with respect to unemployment benefits as observed in data for the US. In turn, this lowers the welfare improvements that can be achieved by a different design of the unemployment insurance system because improving job-finding rates reduces non-search time at the expense of the unemployed. This finding indicates that the welfare figures we report in the benchmark experiment are not specific to the assumption of matching frictions. That is, assuming a different structure for labor market frictions, we find that the parameters needed to rationalize those frictions imply similar welfare figures. Thus, the nature of labor market frictions seems less relevant for the overall welfare figures than for explaining the underlying mechanism.

The final remarks concern the slight difference in welfare effects between low- β and high- β workers in the matching model vs. in the search effort model. As indicated in the bottom panel of Table 5, high- β workers benefit more from the policy change than their impatient counterparts. There is even evidence that front-loading the benefit system is detrimental to low- β workers in the right columns of Table 5 (the welfare effect is slightly hump-shaped for this group). In Appendix B, we perform several additional experiments using the search effort model (i.e., varying the generosity, duration and eligibility of unemployment insurance in the baseline scenario) and show that this result is robust across experiments. The explanation can be found by comparing the returns per unit of search efforts for low- β and high- β workers. Since impatient workers discount these returns by a higher discount rate, they need to compensate by exerting more search efforts and hence by incurring a greater utility cost. Thus, unemployed workers whose asset holdings approach the borrowing constraint undergo more distress through search efforts when they have a lower discount factor. This argument is absent from the matching model where the only difference between low- β and high- β workers is in their ability to build up precautionary savings.

6 Conclusion

We studied the welfare effects of front-loading the payment of unemployment benefits in an equilibrium matching model with precautionary savings. In the absence of access to savings, previous studies have established that, under matching frictions, unemployment benefits should fall with duration from an initial level equal to the wage. Precautionary saving strategies have potential to mitigate the improvements brought by such unemployment benefit schemes, especially if the labor market displays high transition rates between employment and unemployment. Our contribution is to quantify the welfare implications of a similar re-design of the unemployment insurance system when workers are allowed to self-insure against risk. We specialized the discussion to US data and policies. In the baseline scenario, the unemployment insurance pays a constant benefit that

amounts to 45 percent of the wage and expires after 6 months. An alternative is, for example, to collect 2.5 monthly wages immediately after job loss. Our results show that front-loading the benefit system brings significant welfare gains for new benefit recipients and positive gains in the aggregate, even after taking into account general equilibrium effects.

The crux of our analysis was based on a Mortensen-Pissarides matching framework. To put the results in perspective, we repeated the policy experiment using a search effort model, also set within a state-of-the-art calibrated incomplete market economy. The primitives of this model result in welfare figures that line up with the matching model. There are differences in the underlying mechanisms, which are explained by the relationship between an individual's optimal search effort and his/her own ability to build up savings in the model. This is reminiscent of the idea that there may be two different factors that lead to an increase in search effort: restored work incentives (moral hazard) or more financial distress (liquidity effect), as in Chetty (2008).

In this paper, the trade-off behind front-loading the payment of unemployment benefits was a standard one: fewer means to smooth consumption at long unemployment durations vs. improved insurance upon job loss. In future work, we would like to investigate other arguments that could justify the provision of unemployment benefits as an initial one-off payment. One such argument is that this would help the unemployed set up their own company if they face limited access to credit. For instance, in France since 2007, unemployed workers are allowed to claim 50 percent of their remaining unemployment benefits if they start up their own company during the unemployment spell ("Aide à la reprise ou à la création d'entreprise"). Finally, in this study, we based our conclusions on steady-state comparisons and abstracted from the politico-economic consequences of the policy change. Further, our findings suggest that switching from unemployment insurance schemes with constant benefits to a system where those can be paid up front has asymmetric implications for on-going and new benefit recipients. An avenue for future work would be to explore this latent insider-outsider conflict. In particular, an open question is on whether the policy change would have to be retroactive to compensate current unemployment benefit recipients.

References

- Abdulkadiroğlu, Atila, Burhanettin Kuruşçu, and Ayşegül Şahin.** 2002. "Unemployment insurance and the role of self-insurance." *Review of Economic Dynamics*, 5(3): 681–703.
- Akın, Ş Nuray, and Brennan C Platt.** 2012. "Running out of time: Limited unemployment benefits and reservation wages." *Review of Economic Dynamics*, 15(2): 149–170.
- Albrecht, James, and Susan Vroman.** 2005. "Equilibrium search with time-varying unemployment benefits." *The Economic Journal*, 115(505): 631–648.
- Alvarez, Fernando, and Marcelo Veracierto.** 2001. "Severance payments in an economy with frictions." *Journal of Monetary Economics*, 47(3): 477–498.

- Cahuc, Pierre, and Etienne Lehmann.** 2000. "Should unemployment benefits decrease with the unemployment spell?" *Journal of Public Economics*, 77(1): 135–153.
- Chetty, Raj.** 2008. "Moral hazard versus liquidity and optimal unemployment insurance." *Journal of Political Economy*, 116(2): 173–234.
- Coles, Melvyn.** 2008. "Optimal unemployment policy in a matching equilibrium." *Labour Economics*, 15(4): 537–559.
- Coles, Melvyn, and Adrian Masters.** 2006. "Optimal unemployment insurance in a matching equilibrium." *Journal of Labor Economics*, 24(1): 109–138.
- Fredriksson, Peter, and Bertil Holmlund.** 2001. "Optimal unemployment insurance in search equilibrium." *Journal of Labor Economics*, 19(2): 370–399.
- Gorbachev, Olga.** 2011. "Did household consumption become more volatile?" *The American Economic Review*, 101(5): 2248–2270.
- Gruber, Jonathan.** 1997. "The consumption smoothing benefits of unemployment insurance." *The American Economic Review*, 87(1): 192–205.
- Hansen, Gary D., and Ayşe İmrohoroğlu.** 1992. "The role of unemployment insurance in an economy with liquidity constraints and moral hazard." *Journal of Political Economy*, 100(1): 118–42.
- Heathcote, Jonathan, Kjetil Storesletten, and Giovanni L Violante.** 2009. "Quantitative macroeconomics with heterogeneous households." *Annual Review of Economics*, 1(1): 319–354.
- Hopenhayn, Hugo A, and Juan Pablo Nicolini.** 1997. "Optimal unemployment insurance." *Journal of Political Economy*, 105(2): 412–438.
- Kocherlakota, Narayana R.** 2004. "Figuring out the impact of hidden savings on optimal unemployment insurance." *Review of Economic Dynamics*, 7(3): 541–554.
- Krueger, Alan B., and Bruce D. Meyer.** 2002. "Labor supply effects of social insurance." *Handbook of Public Economics*, 4: 2327–2392.
- Krusell, Per, Toshihiko Mukoyama, and Ayşegül Şahin.** 2010. "Labour-market matching with precautionary savings and aggregate fluctuations." *The Review of Economic Studies*, 77(4): 1477–1507.
- Mukoyama, Toshihiko.** 2013. "Understanding the welfare effects of unemployment insurance policy in general equilibrium." *Journal of Macroeconomics*, 38(B): 347–368.
- OECD.** 2007. "Benefit systems and work incentives." *OECD Indicators*.

- Petrongolo, Barbara, and Christopher A Pissarides.** 2001. "Looking into the black box: A survey of the matching function." *Journal of Economic Literature*, 39(2): 390–431.
- Shavell, Steven, and Laurence Weiss.** 1979. "The optimal payment of unemployment insurance benefits over time." *Journal of Political Economy*, 87(6): 1347–1362.
- Shimer, Robert, and Iván Werning.** 2008. "Liquidity and Insurance for the Unemployed." *The American Economic Review*, 98(5): 1922–1942.
- Wang, Cheng, and Stephen D Williamson.** 2002. "Moral hazard, optimal unemployment insurance, and experience rating." *Journal of Monetary Economics*, 49(7): 1337–1371.
- Wang, Cheng, and Stephen Williamson.** 1996. "Unemployment insurance with moral hazard in a dynamic economy." *Carnegie-Rochester Conference Series on Public Policy*, 44: 1–41.
- Young, Eric R.** 2004. "Unemployment insurance and capital accumulation." *Journal of Monetary Economics*, 51(8): 1683–1710.
- Zeldes, Stephen P.** 1989. "Consumption and liquidity constraints: an empirical investigation." *Journal of Political Economy*, 97(2): 305–46.

A Appendix: Search effort model

This appendix describes the competitive equilibrium of the search effort model. For ease of exposition, the model is presented using a unique discount factor for agents (see the numerical appendix for details about the version of the two models with heterogeneous discount factors).

To save on the number of symbols, we use the same notations as in the matching model when there is no ambiguity.

A.1 The model

A.1.1 Environment

Demographics, preferences and search frictions

Just like the matching model, the search effort model is populated by a unit continuum of individuals with stochastic working and retirement life spans. Workers have their preferences ordered by equation (23) in the text. They are separated from their job by the retirement shock or by the λ shock. They can move back into work by exerting search efforts, as described in equation (24).

Technology

Output is produced by means of a neoclassical production function analogous to equation (4). That is, the production technology combines physical capital and labor in a Cobb-Douglas fashion:

$$F(k, \ell) = k^\alpha \ell^{1-\alpha} \tag{25}$$

where ℓ denotes total labor inputs. Physical capital is rented at price r from a competitive market at the beginning of every period and depreciates at rate δ per unit of time. The net real interest rate is $r - \delta$.

Prices determination

Since there is no heterogeneity of labor, the search model can be described as having a centralized labor market where production is carried out by a representative firm. When the firm operates competitively, we can use marginal product conditions to pin down the equilibrium wage and interest rates. That is, prices follow from maximizing

$$F(k, \ell) - rk - (1 + \tau)w\ell \tag{26}$$

with respect to capital k and labor ℓ . w is the wage earned by employed workers and τ is the payroll tax paid to the government.

Other features

Owing to the existence of a single wage level, unemployment benefits and social assistance benefits can be specified as a function of w . That is, disposable income of a currently insured (resp. uninsured) unemployed individual is given by b_1w (resp. b_0w). b_1 and b_0 hence represent “true” replacement ratios. This implies that the budget constraint of the government depends on the equilibrium allocation of workers only.

A.1.2 Bellman equations

Denote by R is the value of being retired, U the value of unemployment and by W the value of being employed to the worker. Retirees solve the same problem as in the matching model: R is the given by equation (8) in the text. On the other hand, the unemployed solve a different problem as they also choose search intensity. Finally, since the search effort model features a centralized labor market, there is a single value function W for employed workers.

Unemployed workers whose current eligibility status for receiving unemployment benefits is given by $i \in \{0, 1\}$ solve the problem:

$$U_i(a) = \max_{a', s} \left\{ \log(c) + A \frac{(1-s)^\gamma - 1}{\gamma} + \beta(1-\sigma) \left(\pi(s)W(a') + (1-\pi(s)) \sum_{j=0,1} p_{i,j}U_j(a') \right) + \beta\sigma R(a') \right\} \quad (27)$$

subject to

$$\begin{aligned} c + a' &\leq (1+r-\delta)a + b_iw \\ a' &\geq 0 \\ s &\in [0, 1] \end{aligned}$$

Employed workers receive a wage w and they solve:

$$W(a) = \max_{a'} \left\{ \log(c) + \beta(1-\sigma) \left(\lambda \left(p_e U_1 \left(a' + \frac{b_f w}{1+r-\delta} \right) + (1-p_e)U_0(a') \right) + (1-\lambda)W(a') \right) + \beta\sigma R(a') \right\} \quad (28)$$

subject to

$$\begin{aligned} c + a' &\leq (1+r-\delta)a + w \\ a' &\geq 0 \end{aligned}$$

Associated with (27) are decision rules for asset holdings $\bar{a}_i^U(a)$ and optimal search intensities $\bar{s}_i(a)$, both of which are indexed by $i \in \{0, 1\}$. Associated with equation (28) is a decision rule for asset holdings $\bar{a}^W(a)$.

A.1.3 Prices determination

The competitive wage and interest rate derive from the profit-maximization program of the representative firm. When the aggregate labor input is ℓ and the capital stock is \bar{k} , the first-order conditions are

$$w = \frac{1-\alpha}{1+\tau} \left(\frac{\bar{k}}{\ell}\right)^\alpha = \frac{1-\alpha}{1+\tau} \tilde{k}^\alpha \quad (29)$$

$$r = \alpha \left(\frac{\bar{k}}{\ell}\right)^{\alpha-1} = \alpha \tilde{k}^{\alpha-1} \quad (30)$$

where \tilde{k} is the capital labor ratio (we introduce it to emphasize symmetry with the matching model). Aggregate labor and physical inputs are obtained as

$$\ell = \int_A d\mu^W(a) \quad (31)$$

$$\bar{k} = \int_A a d\mu^R(a) + \int_A a d\mu^W(a) + \sum_{i=0,1} \int_A a d\mu_i^U(a) \quad (32)$$

A.1.4 Government budget

The balanced budget condition of the government is

$$\tau \int_A d\mu^W(a) = \sum_{i=0,1} b_i \int_A d\mu_i^U(a) + b_f \Omega \quad (33)$$

where Ω is the number of new entrants into the insured unemployment pool. This is given by $\Omega = p_e \lambda (1 - \sigma) \int_A d\mu^W(a)$.

A.1.5 Equilibrium

A competitive equilibrium of the search model is a set of decisions rules for asset holdings ($\bar{a}^R(a)$, $\bar{a}_0^U(a)$, $\bar{a}_1^U(a)$, $\bar{a}^W(a)$) and search intensities ($\bar{s}_0(a)$, $\bar{s}_1(a)$), a distribution of workers across assets and labor market status given by ($\mu^R(a)$, $\mu_0^U(a)$, $\mu_1^U(a)$, $\mu^W(a)$) and a tuple (τ, r, w) such that:

1. Workers optimize: Given (τ, r, w) , asset holding decisions $\bar{a}^R(a)$, $\bar{a}_0^U(a)$, $\bar{a}_1^U(a)$, $\bar{a}^W(a)$ and search decisions $\bar{s}_0(a)$ and $\bar{s}_1(a)$ solve the inner maximization problem in the Bellman equation of workers and retirees.
2. The representative firm optimize: Given (τ, r, w) , optimal demands for labor ℓ and capital \bar{k} are given by the representative firms' first-order condition.
3. The markets clear: (τ, r, w) implies that the aggregate labor and capital inputs ℓ and \bar{k} are consistent with the distribution $(\mu^R(a)$, $\mu_0^U(a)$, $\mu_1^U(a)$, $\mu^W(a))$ in the market clearing equations (31) and (32).

4. The budget is balanced: The payroll tax rate τ is determined by the distribution $\mu_0^U(a)$, $\mu_1^U(a)$ and $\mu^W(a)$ through equation (33).
5. The distribution is time-invariant: $(\mu^R(a), \mu_0^U(a), \mu_1^U(a), \mu^W(a))$ is stationary for the set of decisions rules for asset holdings $(\bar{a}^R(a), \bar{a}_0^U(a), \bar{a}_1^U(a), \bar{a}^W(a))$ and search intensities $(\bar{s}_0(a), \bar{s}_1(a))$.

The time-invariant condition stated in (5) is straightforward to deduce from the Bellman equations (27) and (28). As in the matching model, when writing this law of motion, it is assumed that asset holdings of the dead are redistributed to newborn workers and that the latter are initially in the uninsured unemployment state.

A.2 Calibrated version

The calibrated version of the search effort model uses the parameter values reported in Table 1 for: ψ , β_h , β_l , σ , ζ , α , δ and λ . The additional parameters that pertain to the economic environment are: $\xi = 0.984$, $\gamma = 0.984$ and $A = 12.498$. The parameters that describe unemployment insurance and social assistance are: $b_1 = 0.45$, $b_0 = 0.05$, $p_0 = 0.2492$ and $p_e = 0.267$.

To assist with the comparison of the two economies, Figure A1 displays selected policy functions of the search effort model. The upper graphs show the optimal search efforts of the unemployed. The lower graphs show the net saving decisions of all types of workers.

Beginning with the upper graphs, search efforts are always lower for the insured than for the uninsured unemployed and they also decline steeply with asset levels. This indicates that the calibrated version implies a large heterogeneity in job-finding rates despite having a centralized labor market.²⁷ For example, in the benchmark economy, the average (monthly) job-finding rate is 45 percent. This masks an average job-finding rate of 75 percent (resp. 77 percent) among low- β (resp. high- β) workers who are uninsured unemployed, and an average job-finding rate of 17 percent (resp. 28 percent) among low- β (resp. high- β) workers who are insured unemployed.²⁸ Of course, these differences are partly driven by composition effects, i.e., the fact that the distribution of assets differs across these different types of agents.

Turning to the lower graphs, the consumption-saving behaviors of workers in the search effort model appear similar to those in the matching model. Indeed, when comparing of Figure A1 with Figure 1 in the text, we observe that the shape of net-saving decisions, the scale on the x-axis and the threshold above which agents stop accumulating assets are similar in the two models. Thus, although workers face labor market frictions of different natures, the comparisons we draw in Section 5 are not contaminated by differences in consumption-saving behaviors across models.

²⁷The calibrated value of ξ makes the job-finding probability in (24) close to linear; it is thus straightforward to map search efforts in Figure A1 onto job-finding rates.

²⁸These differentials explain why $p_e = 0.267$ achieves the targeted value of 33 percent for the insured unemployment rate. Unemployment durations are longer for the insured unemployed, which is why they need not account for a large inflow of entrants to constitute a large share of the stock of unemployed persons.

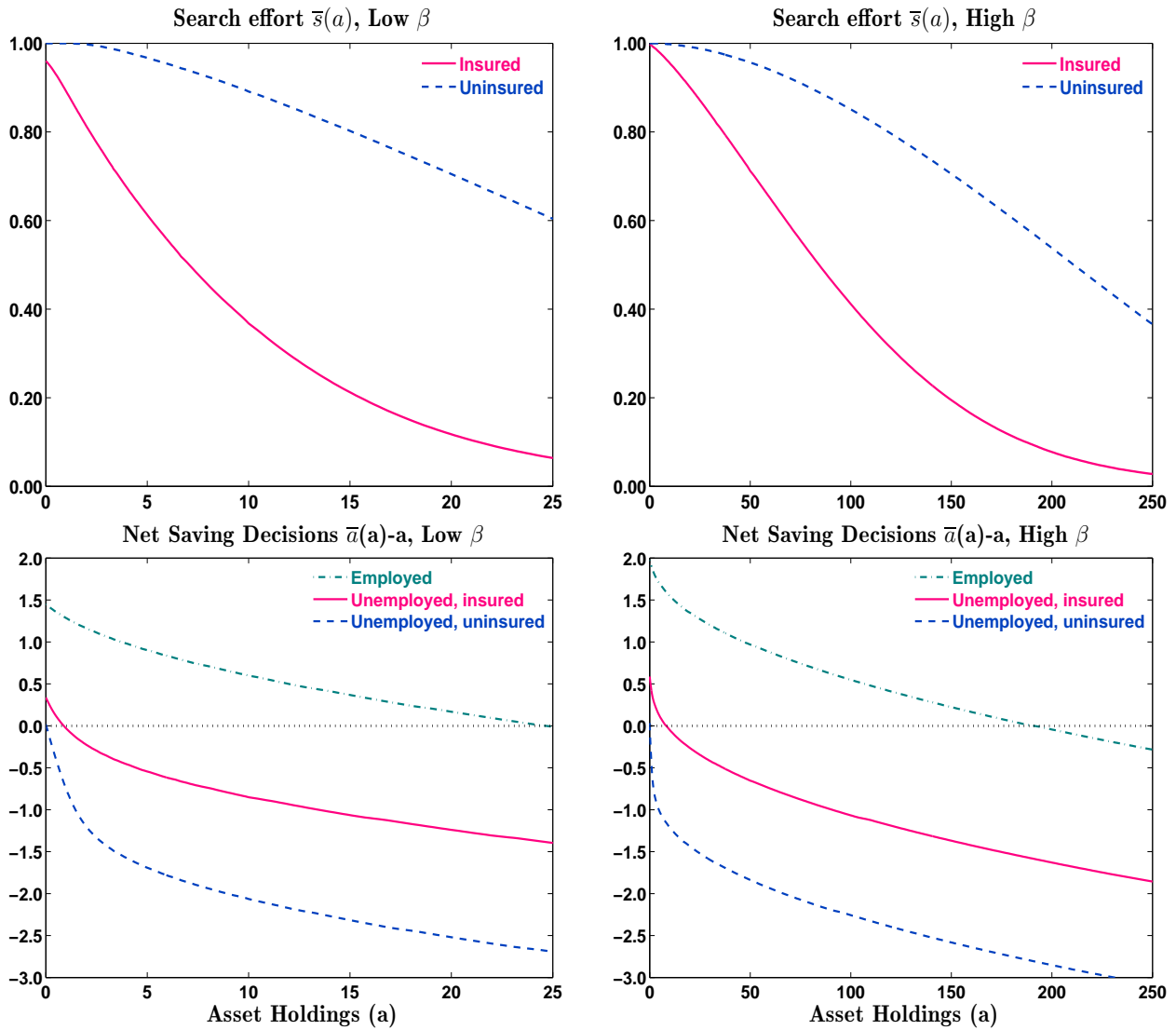


Figure A1. Selected outcomes of the benchmark economy (search effort model)

NOTE: The upper graphs plot the optimal search efforts of the unemployed $\bar{s}(a)$. The lower graphs plot the policy functions for net savings $\bar{a}(a) - a$. The scale on the x-axis is different for the left and right graphs since the plots are shown for the relevant range of asset levels only.

B Appendix: Additional tables

This appendix reports the results of several additional experiments.

Other experiments in the matching model

Table B1 reports the effects of changing the baseline scenario, i.e., varying the cumulative sum of benefits (Subsection 4.3). Specifically, in the experiments we study 50 percent deviations above and below in parameters that govern the generosity and duration of unemployment benefits. In columns (Ia) and (Ib) the baseline replacement ratio is set to 30 percent, and to 60 percent in columns (IIa) and (IIb).²⁹ In columns (IIIa) and (IIIb) the baseline (expected) duration is set to 3 months, and to 9 months in columns (IVa) and (IVb).³⁰

These experiments deliver figures that line up well with the figures based on the benchmark specification. In particular, we find similar labor market effects of front-loading the benefit system when varying the generosity or the duration of benefits. As discussed in Subsection 4.3, the interesting results pertain to a comparison of experiments in columns (IIa)–(IIb) vs. columns (IVa)–(IVb). The welfare gains are significantly larger in the latter because front-loading the benefit system gives workers access to benefits that usually they do not collect.

Other experiments in the search effort model

Table B2 reports the effects of changing key parameters of the unemployment insurance system in the search effort model. As in Table B1, we consider the effects of 50 percent deviations above and below in the generosity (columns (I)–(II)) and duration (columns (III)–(IV)) of benefits. In addition, in columns (V)–(VI), we report the effects of 50 percent deviations in p_e , the probability to collect unemployment benefits upon job loss. These experiments offer robustness checks for the results reported in Table 5 of the paper.

²⁹A replacement ratio of 30 percent obtains when $b_1 = 0.825$; a replacement ratio of 60 percent obtains when $b_1 = 1.640$.

³⁰To save on space, in the table we report only the effects of front-loading the whole payment of unemployment benefits. The numerical experiments were also performed with intermediary levels of front-loading and those delivered convergent findings.

Table B1. Quantitative effects of front-loading the benefit system: Changing the baseline scenario

	Generosity				Duration			
	Low		High		Low		High	
	(Ia)	(Ib)	(IIa)	(IIb)	(IIIa)	(IIIb)	(IVa)	(IVb)
Tax rate τ (%)	0.98	2.12	1.79	4.31	1.37	1.98	1.41	4.50
Up-front benefit \tilde{b}_f	0.00 w	1.01 w	0.00 w	2.27 w	0.00 w	0.80 w	0.00 w	2.50 w
<i>Equilibrium:</i>								
Unemployment (%)	6.91	6.73	7.08	6.71	6.79	6.67	7.08	6.71
Average wage w	100.00	99.03	100.00	98.18	100.00	99.20	100.00	97.53
Assets	100.00	98.88	100.00	97.50	100.00	99.96	100.00	96.41
Consumption	100.00	99.76	100.00	99.47	100.00	100.05	100.00	98.87
<i>Welfare, New entrants:</i>								
Average, low β	100.00	100.78	100.00	101.79	100.00	100.32	100.00	102.19
Average, high β	100.00	100.19	100.00	100.38	100.00	100.10	100.00	100.58
Poorest, low β	100.00	103.03	100.00	104.04	100.00	101.36	100.00	105.23
Poorest, high β	100.00	101.11	100.00	101.60	100.00	100.52	100.00	102.11
<i>Welfare, Aggregate:</i>								
Average, low β	100.00	100.11	100.00	100.31	100.00	100.05	100.00	100.39
Average, high β	100.00	100.02	100.00	100.02	100.00	100.02	100.00	100.11
Average	100.00	100.04	100.00	100.08	100.00	100.03	100.00	100.17

NOTE: Statistics without meaningful units of measurement (wage, assets and consumption) are normalized to 100.0 in the steady-state equilibrium of the benchmark economy. Welfare effects (defined in equation (22)) are expressed in percentage points; they measure changes relative to the benchmark economy. Columns whose label ends with an “a” are for the steady-state equilibrium of the benchmark economy; columns whose label ends with a “b” report the effects of front-loading the payment of unemployment benefits relative to the benchmark. Low generosity (Ia and Ib) indicates a replacement ratio of 30 percent; High generosity (IIa and IIb) indicates a replacement ratio of 60 percent. Low duration (IIIa and IIIb) indicates a duration of benefits of one quarter; High duration (IVa and IVb) indicates a duration of benefits of three quarters.

Table B2. Sensitivity analysis for the effects of front-loading the benefit system in the search effort model

	Generosity				Duration				Eligibility			
	Low		High		Low		High		Low		High	
	(Ia)	(Ib)	(IIa)	(IIb)	(IIIa)	(IIIb)	(IVa)	(IVb)	(Va)	(Vb)	(VIa)	(VIb)
Tax rate τ (%)	0.79	1.42	2.30	2.83	0.90	1.18	1.84	3.07	0.83	1.21	1.87	3.02
Up-front benefit \tilde{b}_f	0.00w	1.01w	0.00w	2.22w	0.00w	0.80w	0.00w	2.44w	0.00w	1.61w	0.00w	1.63w
<i>Equilibrium:</i>												
Unemployment (%)	6.18	5.62	8.14	5.68	6.03	5.61	7.92	5.73	6.32	5.63	7.58	5.72
Wage w	100.00	99.36	100.00	99.50	100.00	99.73	100.00	98.77	100.00	99.64	100.00	98.83
Assets	100.00	100.52	100.00	102.54	100.00	100.41	100.00	102.20	100.00	100.65	100.00	101.89
Consumption	100.00	100.58	100.00	102.67	100.00	100.44	100.00	102.38	100.00	100.74	100.00	102.04
<i>Welfare, New entrants:</i>												
Average, low β	100.00	101.25	100.00	102.35	100.00	100.58	100.00	103.24	100.00	101.78	100.00	101.96
Average, high β	100.00	100.39	100.00	101.08	100.00	100.20	100.00	101.22	100.00	100.60	100.00	100.77
Poorest, low β	100.00	103.39	100.00	105.84	100.00	101.76	100.00	107.05	100.00	104.41	100.00	104.66
Poorest, high β	100.00	101.42	100.00	103.05	100.00	100.78	100.00	103.40	100.00	101.97	100.00	102.29
<i>Welfare, Aggregate:</i>												
Average, low β	100.00	100.02	100.00	100.29	100.00	100.02	100.00	100.22	100.00	100.06	100.00	100.15
Average, high β	100.00	100.04	100.00	100.33	100.00	100.03	100.00	100.26	100.00	100.08	100.00	100.19
Average	100.00	100.04	100.00	100.32	100.00	100.03	100.00	100.25	100.00	100.07	100.00	100.18

NOTE: Statistics without meaningful units of measurement (wage, assets and consumption) are normalized to 100.0 in the steady-state equilibrium of the benchmark economy. Welfare effects (defined in equation (22)) are expressed in percentage points; they measure changes relative to the benchmark economy. Columns whose label ends with an “a” are for the steady-state equilibrium of the benchmark economy; columns whose label ends with a “b” report the effects of front-loading the payment of unemployment benefits relative to the benchmark. Low generosity (Ia and Ib) indicates a replacement ratio of 30 percent; High generosity (IIa and IIb) indicates a replacement ratio of 60 percent. Low duration (IIIa and IIIb) indicates a duration of benefits of one quarter; High duration (IVa and IVb) indicates a duration of benefits of three quarters. Low eligibility (Va and Vb) indicates a 50 percent lower probability of collecting benefits; High eligibility (VIa and VIb) indicates a 50 percent higher probability of collecting benefits.

C Appendix: Numerical methodology [Not intended for publication]

This appendix outlines the numerical methodology for computing equilibria of our model economies.

Computation with homogeneous discount factors

The first step consists in discretizing the asset space. In practice, it is necessary to work with at least two distinct grids: one for value functions and one for the support of the ergodic distribution. We also use another grid for the wage functions. The grids for wage and value functions are made more dense in the lower part of the asset space while the other grid approximates the asset space with evenly-spaced points. The grids used for the computations of the paper have 100, 300 and 1500 points, respectively. Making the grids finer increases computation time without producing significant changes to the results.

The system of Bellman equations is solved via backward induction. For retired persons, the guess-and-verify method provides a closed-form solution of the Bellman equation. For those in the labor force, the numerical solution combines interpolation and a golden-section search method to find the optimal policy for asset holdings. Notice that in the presence of a positive value for b_f , knowledge of $U_1(\cdot)$ above the upper limit of the asset grid is required. In practice, regressing $U_1(\cdot)$ against a second order polynomial of assets for the last 20 grid points yields a R-square indistinguishable from 1 to at least 4 decimal places. A highly accurate prediction can thus be obtained by using the associated OLS coefficients.

At this stage of the computations, each model has some specific modelling features that deserve special treatment:

- In the matching model of Section 2, we need to solve for firms' asset values $J_i(\cdot)$ with $i \in \{0, 1, +\}$ after obtaining the asset holding decisions of workers. This can be done via value function iteration.
- In the search effort model of Section 5, we need to solve for optimal search intensities. Those are obtained by making use of the first-order condition for search efforts, taking into account that s is constrained to lie in the interval $[0, 1]$.

In addition, the wage functions (matching model) must satisfy Nash bargaining (condition (3) of the equilibrium). The computation of all Bellman equations thus has to be nested within a loop for wage functions. After obtaining new value functions, wages are computed by maximizing the Nash product in equations (13) and (14) (the algorithm uses a bisection method to solve for wages in the first-order condition associated with (13) and (14)). This step is repeated until convergence.

The stationary distributions are computed by iterating on the discretized version of the law of motions until pointwise convergence occurs.

Finally, the outer loops involve (i) solving for the interest rate and (ii) solving for the payroll tax rate. The free entry condition implies an additional outer loop to solve for labor market tightness (condition (5) of the equilibrium defined in 2.5).

Computation with heterogeneous discount factors

With heterogeneous discount factors, we adapt the above methodology as follows. First, the grids become type-specific, *i.e.* there are different grids for low- β and high- β agents. Since the grids for low- β agents span a restricted range of values, they can all be made of evenly spaced points. We then repeat the methodology just described:

- Solve for the Bellman equations and obtain the invariant distributions separately for low- β and high- β agents. Notice that we also need to solve for the wage functions of low- β and high- β agents separately.
- Aggregate across agents to obtain equilibrium tuples. That is, scale each type according to its population size as given by χ (see Table 1) and check the market clearing and balanced budget conditions. The aggregation step must be performed before checking the free-entry condition.

Computation of the up-front benefit b_f

The expected discounted cumulative value of unemployment benefits depends on ζ , which is an equilibrium object. To compute equilibria with front-loaded benefits, there is hence an additional loop to solve for the up-front benefit b_f . In practice, we iterate on b_f until convergence; after each update, we solve for the interest rate (and also for labor market tightness and wage functions in the matching model).